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A study was designed to determine if the results of a previous investigation could be duplicated, and if so, whether the observed effect was independent of content. The results of the earlier study had indicated that shifting from one form or "code" of expression to another inhibits a student's ability to express a concept explaining a physical change (cause-effect relationship) but does not inhibit his description of that change. Three sets of demonstrations were developed and were presented on three different days to 289 advanced fourth graders from 12 schools. Each class was divided randomly into four treatment groups. Subjects watched a demonstration and then wrote or drew their answers to the questions, "What happened?" and "Why?" The same demonstration was repeated a second time with slightly different materials. Shifting expression groups (S) either drew first and wrote second or the reverse. Repeating expression groups (R) wrote or drew both times. Both the mean R-S difference score and a regression analysis, which treated each subject's score as a separate entity, favor repetition over shifting for correct concept expression. Since all subjects were fourth graders, it is possible that the phenomena noted are developmental and therefore would be absent in older or younger subjects. Appended are the descriptions of the materials and instructions, and the tables developed in the analyses. (LS)

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THE EFFECTS OF SHIFTING MEDIUM OF EXPRESSION ON THE USE OF CONCEPTS AMONG CHILDREN

Cooperative Research Project No. OE6-10-338

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PROBLEM

Many ideas can be expressed in more than one medium of expression such as oral or written language, mathematics, pictorial representation and so on, each of these involving distinct communication codes. What is the effect of having to shift from one code to another in learning or performance? This is the general problem being considered.

It is common to encounter students who can give verbal statements of mathematical principles but who fail to make use of these principles when opportunity arises in the course of trying to solve problems. Similarly, there are students in the various sciences who can give verbal statements of principles, but who fail to recognize the operation of that principle in a specific situation. Conversely, many people who are performing operations successfully that involve the use of these principles cannot give a verbal statement of them. Frequently people can describe something verbally but cannot draw a picture of it. On other occasions the reverse is found. In short, it sometimes appears that a principle or a concept that is formed in, say, a verbal context is difficult to use if some other form of expression is required, whether the form be pictorial, symbolic, operational or physical action, or some other code of expression. The various phenomena to which we have just referred may be explained in a variety of ways. One possibility is that the shifting of the form of expression, in and of itself, constitutes at least part of the difficulty.

The significance of this problem for education has long been recognized. Failure to transfer school learning to a variety of situations always has been one of the major difficulties facing educators. In addition, there has been a great deal of confusion about points which are related to this particular issue. First, there have always been educators who describe much that goes on in schools as "mere verbalism" because the words learned do not necessarily lead to action. There is, on the other hand, a great deal of evidence that in many instances learning words for things greatly facilitates both further learning and use of prior thinking and learning. This is an apparent contradiction.

Second, there are a number of arguments and controversies in the educational literature concerning the guidance of learning and "learning by discovery," which are also arguments about transfer of training and again refer to situations in which sometimes the criterion performance has required the student to use a different medium of expression that that used in the training. Some studies seem to show that students who "discover" concepts for themselves make use of the concepts more readily than students told the concepts, yet other studies lead to the opposite conclusion.

The form of expression used in the original learning and transfer situations is a variable not usually considered in the studies of these issues. In a prior study, Wilder and Green obtained evidence supporting the notion that these arguments and apparent contradictions could be settled or reduced by making allowance for the difficulty in shifting code. They found that shifting form of expression or code interfered with expressing an explanatory concept but not with straight description. The content dimensions tentatively identified (explanation and description) are not sufficiently clear to enable one to judge properly the relevance of the Wilder and Green data to the problems of transfer identified above.

Therefore the specific portion of the general problem explored in this study is the content dimensions which produced the different result in the prior study. (1) Does shifting code inhibit expression of other explanatory concepts? (2) Is shifting code irrelevant to the description of other physical phenomena? (3) Could the inhibiting effect have appeared in the cause and effect concept (explanatory) scores and not in the discrimination (description) scores because of some unidentified artifact in the first set of materials used?

In view of the consistency of the results obtained previously (the effect appeared in each of the separate classrooms), and because of the potential explanatory power of the phenomena if broadly confirmed, it seemed worthwhile to explore the particular questions posed above. It was the purpose of this study to obtain evidence relevant to these questions by replicating the Wilder-Green study using a variety of learning materials, each containing a cause and effect concept and discriminations as before.

OBJECTIVES

The main objective of the study was to obtain evidence as to the degree to which the effect noted previously by Wilder and Green is a general phenomenon independent of material or content. Specifically then, the objectives were:

a. To confirm, with different materials, the results of that previous investigation (i.e., that shifting from one code of expression to another inhibited the expression of a concept which explained a physical change, but did not inhibit the description of that change).

b. To explore the reasons for the difference in the influence of shifting medium on discrimination and concept scores.

RELATED LITERATURE

The initial study (see reprint attached) pointed out three relevant phenomena reported in previous research:

a. In a number of the most frequently cited studies of problem solving and concept development, the groups who learned verbal principles for solving non-verbal problems did less well than groups who learned the principle non-verbally. An example of this outcome can be seen in Katona's famous matchstick problems: the most successful group by both retention and transfer criteria was instructed visually but not verbally. A group told, then shown the principle involved did less well. Explanations of these and many similar findings that have been reported since have referred to meaning and understanding (e.g. Katona, 1940), set (e.g. Maier, 1930), motivation and practice (e.g. Kersh, 1962). Each of these theories appears reasonable as do some others. Since they differ in terminology, variables considered, and criteria stressed, choices among them are matters of personal preference.

b. None of these theories can deal reasonably with a second phenomenon noted by Smoke (1932), Buswell (1956), and Corman (1957), namely: the difficulty in verbalizing principles derived inductively without the use of words. This is a common phenomenon and seems related to the first kind. It has attracted much less attention and has little theorizing. Yet Hendrix (1948) and Schwartz (1955) note this phenomenon and take it to support their theories concerning a third phenomenon which they have reported.

c. This third sort of phenomenon is the apparently negative consequence of forced verbalization of inductively derived principles on retention and transfer. Hendrix and Schwartz both report not only difficulty in getting subjects to verbalize principles, but also less adequate performance among subjects forced to do so than from those not so forced. The theoretical positions of Hendrix and Schwartz can accommodate all three phenomena described but do not allow for the positive role which verbalization can play in concept development and problem solving. For example, in the Katona study cited, the group given a verbal presentation of the principle surpassed a group given no help at all. A recent report by Wittrock (1963) is but one of many suggesting that verbal directions by teachers and verbal mediation by students have facilitating effects.

There seems, in short, to be confusion in the area. The reviews of the literature on learning by discovery by Ausubel (1961) and by Kersh and Wittrock (1962) document this confusion. Confirmation of our hypothesis could eliminate many of the apparent contradictions now found in this literature.

With respect to the concept dimensions it appears from the research of others (e.g., Long and Welch, 1941; 1942), as well as from our own previous study, that degree of abstractness might be a relevant dimension. We found that the discrimination scores behaved differently from the concept scores, and that at least one difference between these kinds of scores is degree of abstractness. While degree of abstractness is one of a large number of dimensions proposed for the analysis of concepts, we are not really concerned at this stage of our investigations with anything more than determining the relevance of the particular features to be found in the learning materials we are using. In other words, we want to know why the discrimination scores differed from the concept scores in our previous study. For this purpose , it seems appropriate to remain at a descriptive level until further data are obtained.

PROCEDURE

I. Materials

The first step in the project was to develop materials for experiments which paralleled those used in the previous study such that the experiments could be performed in one session instead of the two weeks required by the plants. In the previous study, the plant cuttings received two different amounts of light which caused them to grow differently sized leaves, roots, etc. This was taught by demonstration only. The children watched without talking while two identical cuttings were made from the coleus plant. One cutting was placed in a sunny window, the other in a bookcase. The children were told to watch the plants for two weeks, at which time E would return to ask them "What happened?" and "Why?" They were not to discuss the plants with anyone until E told them the experiment was completed.

The materials to be developed had to meet certain requirements:

1. Again the concept had to be taught by demonstration only. This was necessary because any instruction using a code of expression would affect the subsequent expression of the children's learning.

2. The concepts used had to be similar in form but not in content. Two plant cuttings received different amounts of light, causing them to grow differently. This idea was called the cause and effect concept (CE).

In the new experiment, the agent had to occur in a greater and lesser amount and act upon something to cause change. Also, the things acted upon, as was the case with the plants, would have to change in a discriminably different manner to two different amounts of the agent. The end result had to be visibly different, permitting us to record a discrimination (D) independent of noting the CE.

3. The agent could be used in only one of the experiments.

4. The CE must be equally easy to express both in writing and in drawing.

5. For the second expression, the materials acted upon bv the agent must be similar, but different from the materials used for the first expression. For in the previous study of the plants, for the second expression, the original coleus plants were replaced by two begonia cuttings not seen before by the children. The children were told: "These were grown just like those you saw grow in the classroom. Now tell what happened and why."

6. Naturally, the materials had to be unfamiliar to the subjects but neither too hard nor too easy for them to understand.

Three sets of materials appropriate to the study were developed and tried out in a number of fourth grade classes in DeKalb County, Georgia, in the Spring of 1965. These were: (a) two different amounts of light caused light sensitive papers to change color, the shades of the color differing with the amounts of light; (b) two different amounts of electricity caused the electromagnets to pick up different bar weights; (c) two different amounts of heat caused crystals in sodium silicate to grow to different sizes. A complete description of these materials can be found in Appendix A.

It may be noted here that in the course of these tryouts, some fourth grade classes characterized as "general" were included (DeKalb tracks students in courses on three levels: advanced, general, basic). The children in these classes typically did not produce adequately scorable protocols.

Partly to check this observation concerning academic status, and partly to further work out some details of the crystals and the papers experiments, two classes were used in which the children had voluntarily elected to attend summer school in the Atlanta City School System. One class was white except for one

Negro child; the other was all Negro. These groups were in schools whose students were known to differ in academic performance and verbal facility in the usual direction. Most of the Negro children did not learn the cause and effect concept. Also, the quality of their writing and drawing was much below that of the other class. Thus it would appear that learning of CE concepts is related to the ability to express oneself. Upon verbal questioning following the completion of the experiment, these children seemed interested and able to learn, but were lacking in any scientific background or training which would enable them to learn from observation.

II Subjects

As in the previous study, subjects were fourth graders taking advanced studies in the DeKalb County School System, a largely white (about 90%) bedroom county, bordering Atlanta, Georgia. Scores from 289 children in 12 schools were used. These schools were in middle class white neighborhoods (the county is very thoroughly segregated; school desegregation remains token), as pilot studies had indicated the need to have subjects with expressive facility if scorable protocols were to be obtained. Thus, at the fourth grade level, it was necessary to select brighter than average subjects from better than average socioeconomic surroundings.

Within each classroom the children were divided into four groups more or less randomly, i.e., haphazardly. This was done by E on the first day in the classroom. The groups were approximately equal in size the first day. They did not stay that way because (a) there were absences (28) on the second or third day, (b) a number of S's (40) both wrote and drew on at least one expression, and (c) a few S's (7) followed treatment sequences not assigned. The scores of these 75 S's can be found in Tables 14 and 15 in Appendix C. The remaining 289 S's were distributed in groups varying from two to ten subjects as shown in Tables 1 and 2.

III Design

As noted above, four groups were set up in each school the first day. These groups were designated WW, DD, WD, and DW indicating whether they wrote (W) or drew (D) on the first and second expressions. In each school, the first

Table 1
Treatments by School and Experiment

School	Group	First Experiment	Second Experiment	Third Experiment	Number of Subjects
CMP1	A	WW	DW	WD	8
	B	DD	WD	DW	7
	C	WD	WW	DD	6
	D	DW	DD	WW	6
CMP2	A	WW	DD	DW	5
	B	DD	DW	WD	5
	C	WD	WW	DD	4
	D	DW	WD	WW	6
CPM1	A	WW	DD	WD	7
	B	DD	WD	DW	2
	C	WD	DW	WW	6
	D	DW	WW	DD	7
CPM2	A	WW	DW	DD	6
	B	DD	WD	WW	7
	C	WD	WW	DW	7
	D	DW	DD	WD	10
MPC1	A	WW	WD	DW	4
	B	DD	WW	WD	6
	C	WD	DW	DD	6
	D	DW	DD	WW	7
MPC2	A	WW	DW	WD	4
	B	DD	WD	DW	5
	C	WD	WW	DD	4
	D	DW	DD	WW	7
MCP1	A	WW	WD	DD	8
	B	DD	DW	WW	6
	C	WD	DD	DW	9
	D	DW	WW	WD	5
MCP2	A	WW	DD	WD	6
	B	DD	WD	DW	6
	C	WD	DW	WW	7
	D	DW	WW	DD	6
PMC1	A	WW	DW	WD	5
	B	DD	WW	DW	4
	C	WD	DD	WW	7
	D	DW	WD	DD	8
PMC2	A	WW	DD	WD	8
	B	DD	DW	DW	5
	C	WD	WW	WW	5
	D	DW	WD	DD	7
PCM1	A	WW	DW	DD	6
	B	DD	WD	WW	6
	C	WD	WW	DW	6
	D	DW	DD	WD	5
PCM2	A	WW	WD	DW	5
	B	DD	WW	WD	5
	C	WD	DW	DD	8
	D	DW	DD	WW	4

Table 2

Frequency Distribution of Treatment Group Size

Size of Group	Frequency	Percentage
10	1	2
9	1	2
8	5	10
7	10	21
6	14	29
5	10	21
4	6	13
3	0	
2	1	2

experiment was done on a Monday with one-third of the schools doing the papers, one-third the magnets, and one-third the crystals; the experiments were systematically varied over schools for the three days as shown in Table 3. The schools were labeled by the sequence of experiments following in that school.

The second experiment was conducted on the Wednesday, and the third on the Friday of the same week. No group had the same treatment twice, i.e., the writing and/or drawing sequence was different on each of the three days. This pattern is shown in Table 1. This arrangement was not the original plan. It developed because of a minunderstanding: the consequence of this confusion is evident in the somewhat awkward procedures used in analyzing the data.

Three E's and a substitute (used six times: magnets four times, crystals once, papers once) presented the experiments to the children. Each E was assigned one of the three experiments, which he presented to each of the 12 schools during a three week period. Thus, any effects apparently due to materials or "experiments" can be equally well considered the effects of the particular E.

These four E's also scored the protocols, each scoring the materials he collected and those of one other. Thus every paper was scored twice. Disagreements were settled by the senior author. The correlation between judges was .96 for CE scores and .99 for D scores -- scoring procedures are described in Appendix B.

IV Classroom Procedure

Each experiment took approximately one hour and thirty-five minutes. In each case, E had the children watch the demonstration, coming up to look closely at the materials in the case of the papers and crystals. Then the S's wrote or drew as directed, answering the questions, "What happened?" and "Why?" Typically, this took them about twenty minutes. Next, a second demonstration with slightly different materials was given, followed by a second attempt to answer the question by drawing or writing. Half of those who drew first wrote, half of those who wrote first drew second, and the remainder used the same medium twice. The details given and the timing are described exactly in Appendix A. After the second expression on the third day (Friday), the whole affair, including each experiment, was explained to the students. This explanation is given in Appendix A.

Table 3

Order of the Experiments

Schools	Monday First Experiment	Wednesday Second Experiment	Friday Third Experiment
CMP1 & CMP2	Crystals	Magnets	Papers
CPM1 & CPM2	Crystals	Papers	Magnets
MPC1 & MPC2	Magnets	Papers	Crystals
MCP1 & MCP2	Magnets	Crystals	Papers
PMC1 & PMC2	Papers	Magnets	Crystals
PCM1 & PCM2	Papers	Crystals	Magnets

RESULTS

The data relevant to the objectives of the study are the changes in score from first expression to second expression as influenced by mode of expression. The first expression, second expression and resulting change scores for each subject and group are shown in Tables 30-52 in Appendix C.

Since the number of pupils in the four treatment groups in each class (school) varied from two to ten (see Table 2), the mean for each treatment group in each school for each set of materials was found and treated as a single score. This procedure avoids any bias from unequal numbers in any treatment in any school with any materials, and balances out all direct drawing and writing effects. To sample each group down to equal numbers would mean sampling down to two subjects per group; this would lead to a large loss in degrees of freedom without the gain in reliability that the use of means achieves.

CE Change Scores

The Papers experiment did not work in schools PCM2 and PMC2; that is, on subsequent examination, it was found that the resulting figure outlines could not be distinguished from each other. Therefore, it was assumed that the non-zero CE change scores were random departures from zero and that estimated scores would be more meaningful. These estimations were based on the deviation of the mean for the school, the materials, the treatment, and the presentation from the grand mean. Table 26 in Appendix C shows the work done in obtaining these estimations. Since these are not experimentally obtained scores, all tests of hypotheses based on these scores must be evaluated with the appropriately reduced number of degrees of freedom.

Table 4 shows the mean CE change scores for each group (Expression II less Expression I with a constant of three added to all the differences to eliminate negative scores) arranged by materials, and Table 5 shows the same scores arranged by experiment, and these two variables are confounded in the design.

The comparison relevant to the principal questions asked is between the shifting scores (WD & DW) and the repetition scores (WW & DD). These pairs of means were combined and the differences between them found (see Tables 16 and 17

Table 4
Mean CE Change Scores
by Materials

School	Crystals				Magnets				Papers				School Mean
	WW	DD	WD	DW	WW	DD	WD	DW	WW	DD	WD	DW	
CMP1	2.62	2.86	2.67	2.00	2.83	3.00	3.00	2.88	2.83	3.17	3.62	2.71	2.85
CMP2	2.80	2.40	2.25	2.50	3.50	3.20	2.83	3.00	2.83	2.75	2.40	2.80	2.77
CPM1	2.29	3.00	3.00	2.71	3.17	3.14	3.43	2.50	2.71	2.86	2.50	3.00	2.86
CPM2	2.33	2.57	2.14	2.40	3.00	3.00	2.90	3.00	2.86	2.80	3.00	2.50	2.71
MPC1	2.57	2.67	1.83	2.50	2.75	2.83	3.33	2.43	3.00	3.57	3.00	2.83	2.78
MPC2	2.86	2.75	2.00	2.80	3.25	3.20	2.50	2.86	2.25	2.86	2.80	2.75	2.74
MCP1	2.20	2.33	1.88	2.50	3.00	2.83	3.11	3.20	3.00	3.00	2.80	2.67	2.71
MCP2	2.50	2.67	2.83	2.29	2.83	3.17	3.00	2.83	2.43	3.00	3.33	2.83	2.81
PMC1	3.00	2.12	1.30	2.50	3.00	3.14	3.25	2.80	2.80	3.00	3.14	2.75	2.78
PMC2	2.60	3.29	2.62	3.00	3.20	3.25	3.29	2.80	3.08E	3.16E	3.01E	2.95E	3.02
PCM1	2.33	2.60	3.00	2.17	3.17	3.00	3.20	3.00	3.00	3.00	1.83	3.00	2.78
PCM2	3.00	1.75	2.40	1.88	3.00	3.25	2.60	2.80	2.65E	2.73E	2.58E	2.52E	2.60
Treat by Material	2.59	2.58	2.37	2.44	3.06	3.08	3.04	2.84	2.79	2.99	2.83	2.78	2.78

E = Estimated score

Table 5
Mean CE Change Scores
by Experiment

	First Experiment				Second Experiment				Third Experiment				
School	WW	DD	WD	DW	WW	DD	WD	DW	WW	DD	WD	DW	Mean
CMP1	2.62	2.86	2.67	2.00	2.83	3.00	3.00	2.88	2.83	3.17	3,62	2.71	2.85
CMP2	2.80	2.40	2.25	2.50	3.50	3.20	2.83	3.00	2.83	2.75	2.40	2.80	2.77
CPM1	2.29	3.00	3.00	2.71	2.71	2.86	2.50	3.00	3.17	3.14	3.43	2.50	2.86
CPM2	2.33	2.57	2.14	2.40	2.86	2.80	3.00	2.50	3.00	3.00	2.90	3.00	2.71
MPC1	2.75	2.83	3.33	2.43	3.00	3.57	3.00	2.83	2.57	2.67	1.83	2.50	2.78
MPC2	3.25	3.20	2.50	2.86	2.25	2.86	2.80	2.75	2.86	2.75	2.00	2.80	2.74
MCP1	3.00	2.83	3.11	3.20	2.20	2.33	1.88	2.50	3.00	3.00	2.80	2.67	2.71
MCP2	2.83	3.17	3.00	2.83	2.50	2.67	2.83	2.29	2.43	3.00	3.33	2.83	2.81
PMC1	2.80	3.00	3.14	2.75	3.00	3.14	3.25	2.80	3.00	2.12	1.80	2.50	2.78
PMC2	3.08E	3.16E	3.01E	2.95E	3.20	3.25	3.29	2.80	2.60	3.29	2.62	3.00	3.02
PCM1	3.00	3.00	1.83	3.00	2.33	2.60	3.00	2.17	3.17	3.00	3.20	3.00	2.78
PCM2	2.65E	2.73E	2.58E	2.52E	3.00	1.75	2.40	1.88	3.00	3.25	2.60	2.80	2.60
Treat by Exper.	2.78	2.90	2.71	2.68	2.78	2.84	2.82	2.62	2.87	2.93	2.71	2.76	2.78

E = Estimated score

in Appendix C). A mean R-S difference score is the combination of all the scores of all the students in the class for that experiment. Drawing and writing per se are fully controlled (i.e., balanced out) in these difference scores.

Table 6 shows the CE change R-S differences arranged first by order of experiment and then by materials, and shows the results of testing the hypotheses that these differences in change scores depart from zero by chance only. All differences favor repetition over shifting and all but one permit rejection of the null hypotheses at standard levels of significance. This analysis indicates that there is a shifting effect in these CE change score differences. CE change scores are higher when code of expression is not changed than when it is. This confirms the result of the previous study (said result justifying the use of a one-tailed test).

Although these mean differences may not seem to be large, the fact that they typically appear within class sized groups after a short period of time suggests that the phenomenon may play a substantial role in school achievement. It can be seen that this shifting effect apparently is not a function of either order of presentation or material unless the two interact so as to mask their effects. The analysis of variance shown in Table 7 support the assertion insofar as acceptance of null hypotheses can be said to be support for the hypotheses.

Another way to approach these questions is to treat each score of each subject as a separate entity and perform a regression analysis of variance, adjusting sequentially and cumulatively for each of the variables discussed. Table 8 shows the results of such an approach looking first at school effects, second at materials, third at order, and fourth at shifting. The second and fourth variables produced significant effects. The two other treatment comparisons chosen were not significant.

This analysis does not adequately control for variance within subjects or for interactions, yet plainly confirms the results of the first analysis. It demonstrates the significance of the differences among the materials in CE change scores. These differences can readily be seen in Table 4. The crystals means exceed 3.00 in only one instance, indicating that, regardless of treatment or school, second expression was more difficult than the first for the crystals. This almost uniform negative transfer appears in a less marked form in the papers not found among the magnet means, which exceed 3.00 as often as not.

Table 6
Mean Cause-Effect R-S Differences
by Experiment and by Materials

	Experiment			Materials			School
School	First	Second	Third	Crystals	Magnets	Papers	Mean
CMP1	0.81	-0.05	-0.33	0.81	-0.05	-0.33	0.14
CMP2	0.45	0.87	0.38	0.45	0.87	0.38	0.57
CPM1	-0.42	0.07	0.38	-0.42	0.38	0.07	0.01
CPM2	0.36	0.16	0.10	0.36	0.10	0.16	0.21
MPC1	-0.18	0.74	0.91	0.91	-0.18	0.74	0.49
MPC2	1.09	-0.44	0.81	0.81	1.09	-0.44	0.49
MCP1	-0.48	0.15	0.53	0.15	-0.48	0.53	0.07
MCP2	0.17	0.05	-0.73	0.05	0.17	-0.73	-0.17
PMC1	-0.09	0.09	0.82	0.82	0.09	-0.09	0.27
PMC2	0.28 E	0.36	0.27	0.27	0.36	0.28 E	0.30
PCM1	1.17	-0.24	-0.03	-0.24	-0.03	1.17	0.03
PCM2	0.28 E	0.47	0.85	0.47	0.85	0.28 E	0.53
Means	0.29	0.19	0.33	0.37	0.26	0.17	0.27
s	0.29	0.38	0.51	0.43	0.47	0.52	0.47
t	1.84*	1.71	2.24	2.97	1.95	1.11*	3.42
p**	0.05	NS	0.03	0.01	0.05	NS	0.005

* df = 9
** one tailed test
E = Estimated score

Table 7.
Analysis of Variance of R-S Differences Among CE Change Scores

Source of Variation	Sum of Squares	df	Mean Square	F	P
Total	7.7489	35			
Between schools	2.0651	11			
Within schools	5.6838	24			
Materials	0.2442	2	0.1221	0.49	NS
Residual	5.4396	22	0.2473		
Experiment	0.1313	2	0.0656	0.27	NS
Residual	5.5525	22	0.2524		

Table 8

Regression Analyses of Variance for CE Change Scores for 820 Subjects in Three Experiments

Variable	df	F	P
School Differences	1 and 808	1.06	NS
Materials (Crystals, Papers, Magnet)	1 and 807	41.50	.005
Experimental Order of Materials	1 and 805	.82	NS
Repeat (WW & DD) V. Shift (DW & WD)	1 and 803	5.48	.05
Write, Draw V. Draw, Write	1 and 802	1.78	NS
Write, Write V. Draw, Draw	1 and 801	1.06	NS

Before discussing possible interpretations of this last phenomenon, the D scores need to be considered, since in the prior study, these appeared to have different interrelationships than the CE scores.

D Change Scores

Tables 9 and 10 show the mean D change scores for each group (Expression II less Expression I with a constant of 5 added to all to eliminate negative scores). Change scores less than five indicate that the second expression was less adequate than the first. Note that, as with the CE change scores, estimated scores (Table 27, Appendix C) are used for the Papers experiment in schools PCM2 and PMC2. Again, as with the CE change scores, repeat (R) and shift (S), D means were found and differences obtained (see Tables 18 and 19, Appendix C).

Tests of the shifting hypotheses are shown in Table 11. In the overall comparison, no significant effect is present nor does any appear when the differences are arranged by materials. When arranged by order of experiment a shifting effect, significant at the .05 level, appears for the third experiment. The most parsimonious interpretation of this last finding is that it represents a type I error. There are five reasons for favoring this interpretation: (a) A conclusion of no shifting effect for D scores was drawn from the previous study; (b) This result is the only comparison of seven that is significant and, as a consequence, it cannot be considered as unlikely an event as rejection at .05 implies; (c) Since neither the overall difference nor those for the first and second experiments are significant, the third experiment must differ from the first two rather than just showing the same trend more clearly if the difference is real rather than chance; the analysis of variance summarized in Table 12 confirms this, and the negative mean for the second experiment also points to the unique character of the experiment III result; yet, no ready explanation for its uniqueness is at hand; (d) No trend toward a greater advantage for repetition after experience is evident among the CE scores; (e) In general, one would expect that practice would help one shift, i.e., a trend opposite to this mean is more readily rationalized.

In sum, as before, the data support a conclusion of no shifting effect for D change scores.

Examination of Tables 9 and 11 will show that magnet scores are more variable than those for the other materials. This is because the possible number of

Table 9
Mean Discrimination Change Scores by Materials

School	Crystals WW	Crystals DD	Crystals WD	Crystals DW	Magnets WW	Magnets DD	Magnets WD	Magnets DW	Papers WW	Papers DD	Papers WD	Papers DW	School Means
CMP1	4.50	4.57	4.67	3.17	4.17	4.83	6.57	3.75	5.50	5.50	6.38	4.29	4.82
CMP2	4.80	4.00	4.20	4.00	5.25	4.80	5.33	4.40	4.50	4.50	4.20	4.00	4.50
CPM1	4.14	4.00	5.50	4.29	5.17	5.71	6.71	3.50	4.43	4.43	4.50	4.33	4.73
CPM2	4.17	5.00	4.29	4.60	4.71	4.83	5.50	4.29	4.57	4.60	5.57	3.83	4.66
MPC1	4.43	4.67	3.50	4.75	5.25	4.83	6.67	3.43	4.83	5.86	5.75	4.50	4.87
MPC2	4.86	4.50	3.50	4.60	5.25	5.40	5.25	4.00	4.00	4.71	5.00	4.75	4.65
MCP1	4.00	4.22	4.38	4.67	5.00	4.83	6.56	4.00	5.17	5.00	5.60	3.67	4.76
MCP2	4.17	4.67	4.83	4.29	4.83	5.17	6.29	3.67	4.14	4.67	5.83	4.50	4.76
PMC1	4.71	3.88	3.80	3.50	4.75	5.29	7.25	4.20	4.80	4.75	5.29	4.25	4.71
PMC2	4.40	5.43	5.00	4.60	5.40	5.50	7.14	3.60	5.10E	5.25E	5.68E	4.43E	5.13
PCM1	4.00	4.60	5.00	3.17	5.00	6.00	6.40	4.00	5.00	4.67	3.67	4.40	4.66
PCM2	5.00	4.00	4.80	3.50	5.00	5.63	4.60	2.60	4.36E	4.51E	4.94E	3.69E	4.39
Treat by Material	4.43	4.46	4.46	4.10	4.98	5.24	6.19	3.45	4.70	4.87	5.20	4.22	4.71

E = Estimated score

Table 10
Mean D Change Scores
by Experiment

	First Experiment				Second Experiment				Third Experiment				School
School	WW	DD	WD	DW	WW	DD	WD	DW	WW	DD	WD	DW	Means
CMP1	4.50	4.57	4.67	3.17	4.17	4.83	6.57	3.75	5.50	5.50	6.38	4.29	4.82
CMP2	4.80	4.00	4.25	4.00	5.25	4.80	5.33	4.40	4.50	4.50	4.20	4.00	4.50
CPM1	4.14	4.00	5.50	4.29	4.43	4.43	4.50	4.33	5.17	5.71	6.71	3.50	4.73
CPM2	4.17	5.00	4.29	4.60	4.57	4.60	5.57	3.83	4.71	4.83	5.50	4.29	4.66
MPC1	5.25	4.83	6.67	3.43	4.83	5.86	5.75	4.50	4.43	4.67	3.50	4.75	4.87
MPC2	5.25	5.40	5.25	4.00	4.00	4.71	5.00	4.75	4.86	4.50	3.50	4.60	4.65
MCP1	5.00	4.83	6.56	4.00	4.00	4.22	4.38	4.67	5.17	5.00	5.60	3.67	4.76
MCP2	4.83	5.17	6.29	3.67	4.17	4.67	4.83	4.29	4.14	4.67	5.83	4.50	4.76
PMC1	4.80	4.75	5.29	4.25	4.75	5.29	7.25	4.20	4.71	3.88	3.80	3.50	4.71
PMC2	5.10E	5.25E	5.68E	4.43E	5.40	5.50	7.14	3.60	4.40	5.43	5.00	4.60	5.13
PCM1	5.00	4.67	3.67	4.40	4.00	4.60	5.00	3.17	5.00	6.00	6.40	4.00	4.66
PCM2	4.36E	4.51E	4.94E	3.69E	5.00	4.00	4.80	3.50	5.00	5.63	4.60	2.60	4.38
Treat by Exper.	4.77	4.75	5.26	3.99	4.55	4.79	5.51	4.08	4.80	4.61	5.08	4.02	4.70

E = Estimated score

Table 11
R-S Discrimination Scores
by Experiment and by Materials

	Experiment			Materials			School
School	First	Second	Third	Crystals	Magnets	Papers	Means
CMP1	1.23	-3.07	0.33	1.23	-3.07	0.33	-0.50
CMP2	0.55	0.32	0.80	0.55	0.32	0.80	0.56
CPM1	-1.65	0.03	0.67	-1.65	0.67	0.03	-0.32
CPM2	0.28	-0.23	-0.25	0.28	-0.25	-0.23	-0.07
MPC1	-0.02	0.44	0.85	0.85	-0.02	0.44	0.42
MPC2	1.40	1.04	1.26	1.26	1.40	-1.04	0.54
MCP1	-0.73	-0.83	0.90	-0.83	-0.73	0.90	-0.22
MCP2	0.04	-0.28	-1.52	-0.28	0.04	-1.52	-0.59
PMC1	0.01	-1.41	1.29	1.29	-1.41	0.01	-0.04
PMC2	0.24 E	0.16	0.23	0.23	0.16	0.24 E	0.21
PCM1	1.60	0.43	1.40	0.43	1.40	1.60	1.14
PCM2	0.24 E	0.70	3.43	0.70	3.43	0.24 E	1.46
Means	0.27	-0.40	0.78	0.34	0.16	0.15	0.22
s	0.90	1.06	1.16	0.89	1.59	0.83	1.13
t	1.04*	-1.31	2.33	1.32	0.35	0.62*	1.15
p	NS	NS	0.05	NS	NS	NS	NS

* df = 9

E = Estimated score

Table 12
Analysis of Variance of R-S Differences
Among Discrimination Change Scores

Source of Variation	Sum of Squares	df	Mean Square	F	p
Total	44.5327	35			
Between schools	13.3189	11			
Within schools	31.2138	24			
Materials	0.2586	2	0.1293	0.09	---
Residuals	30.9552	22	1.4070		
Experiment	7.5530	2	3.7765	3.51*	0.05
Residual	23.6608	22	1.0755		

* df = 2 and 20

discriminations was larger (six in contrast to four). Since the grand mean for D change scores is very close to zero, the simplest way to adjust these scores was to reduce them all by one third. Not only does the mean remain unaffected, but nothing else of any importance is changed either. A complete analysis of the D scores using these modified magnet scores produces t-ratios almost identical to those recorded above. Only the variances are changed by this modification. This analysis is shown in Tables 20-25 in Appendix C. (See also Table 28.) The conclusions are the same. The shifting effect in the CE change scores is not present in the D change scores.

Other Results

It is interesting to note that this conclusion is restricted to the R-S differences. The differences by material in CE change scores noted above are reflected almost exactly in the D scores. Table 13 shows the frequency of means indicating tendencies toward positive or negative transfer. For each set of materials, CE vs. D chi square tests of independence confirm this parallelism, i.e., all null hypotheses can be rejected at less than .01 (see Table 29 in Appendix C).

Almost all the mean D scores for crystals are negative as was the case among the CE scores. In other words, the second set of crystals was harder to describe and harder to explain. In contrast, the magnets apparently created no such problems since both the mean CE and mean D scores were positive as often as not. The frequencies for the papers experiment fall between the other two, that is, there is a tendency for second expression to be more difficult than first (transfer is negative) but the tendency is less marked than in the crystals experiment.

The fact that both CE and D scores show these material effects emphasizes the unique nature of the shifting effect which appears only in the CE scores.

CONCLUSIONS AND IMPLICATIONS

The results of this study fully confirm those of the previous study by Wilder and Green. Clearly, shifting medium or code of expression inhibits the

Table 13

Frequency of Positive and Negative Transfer
Exhibited by CE and D Mean
Change Scores

Score	Direction of Transfer	Material			Total
		Crystals	Papers	Magnets	
CE	Positive	1	8	18	27
	Negative	41	30	19	90
D	Positive	2	13	23	38
	Negative	42	32	22	96

ability to express an inferred causal concept, but does not, in itself, inhibit description of observed characteristics of the material presented. This effect has now been obtained with four different sets of materials. The differences among the materials do not appear worth pursuing in view of the tremendous number of variables that may be involved and in view of their independence of shifting.

There are three points to note in interpreting these data before their relevance to educational practice can be fairly considered. One is that all the subjects in both studies were in the 4th grade. It is, therefore, possible that the phenomena noted are developmental and would not appear among younger or older subjects. For example, in Piaget's schema (Inhelder and Piaget, 1958), children at this age (nine and ten) are in the stage of cognitive development in which they can handle concrete, but not formal logical operations. On this basis, one could infer that older individuals (over twelve) would not have serious problems with shifting medium, while younger children (below seven) could not handle the CE concept at all. The latter part of this assertion is almost certainly the case, but what would happen among intellectually mature students is debatable.

A second point about which the data permit no conclusion is the generality of communication codes and media of expression. (The fact that we have treated these as one and the same raises still another question, which will be ignored.) The research which first stimulated the ideas used here was that of Hendrix (1948). She used spoken words and mathematical symbols, but a shift in code is only one of many possible variables involved in her study and was not studied directly. Not only is it uncertain whether or not shifts between other codes would produce effects, but it is not clear whether the effect obtained is large or small, permanent or transitory.

Finally, there is the question of the features of the CE concepts used which were essential for producing the shifting effect. Simple awareness of the differences plainly is not sufficient, albeit definitely essential at some point. What else is involved? Was it the inference of causation? Was it the number of elements going into that inference? Was it the need to draw an inference alone, i.e., would other sorts of inferences produce a shifting effect? Would it have occurred if the second demonstration had been completed while the children watched as they did the first?

The answers to these questions partly determine the implications of the data for education. Nevertheless, it is evident that, at least among children in the middle grades, requiring a shift in medium of expression can interfere with the adequacy with which students explain inferences about causation. It may further explain many of the puzzling cases of student inability to write down explanations their teachers had been sure they understood, to say nothing of the often incredible errors students commit when working with "word problems" in mathematics.

It is, of course, not known whether it is the expression of the idea or its understanding that is inhibited, but obviously there is some advantage in having students use the code of expression most relevant to the use of the idea learned from the beginning. At least some of the time, our penchant for having students put ideas into words on examinations is at best inefficient and at worst misleading to all, since even the students themselves tend to believe their own test scores.

The domain in which these data have the greatest possibility of helping education is in the design of "discovery learning" procedures which often require students to draw inferences based on observation. In this area, there is much confusion about the amount of "guidance" students should be given. We believe that a re-examination of the research in this domain with the existence of the shifting effect in mind would clarify some of the discrepancies in the data (see, for example, Shulman and Keisler, 1966), since the guidance is often in a different code than that in which the student is working.

Although the nature of the shifting phenomenon still needs exploration, as the uncertainties noted above indicate, some efforts to further improve and systematize instructional procedures calling for discovery might well be undertaken as a consequence of this shifting effect.

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APPENDIX A

Materials and Instructions

General Instructions

All experiments include these instructions.

Children, I am (name of E). I have taught school and liked it very much. but I want to know more about how you learn, so I am doing research at Emory University now.

I am reading this paper because I am going to ask you to take part in an experiment. An experiment, as you probably know, is a way of getting answers to questions when no one knows the answer. A good experiment can be repeated exactly. If everything is written down, the experiment can be done over again to find out if the same thing happens every time.

This experiment will tell me something about how you learn by looking. It is very important that each of you learn for yourself and be on your honor not to talk to one another or look at one another's paper until the experiment is finished.

There will be two lessons today and you will write or draw twice. The papers will be graded, but not become a part of your school grades. Please do the best that you can, for your answers will give me information that no one has yet. I shall write you a letter and tell you what that is as soon as I can. Raise you hand if you have any questions.

(Pass out paper and crayons) Please put your name on your paper. (Check each paper for a name before leaving the classroom) Please follow the instructions on your paper as I read them to you.

Those of you that are to write must write clearly enough for me to understand you. However, if you need to use a word that you can't spell correctly, spell it the best that you can and that will be all right. If you are to draw, the drawing does not have to be beautiful necessarily, but you must draw so I can understand you. I suggest that you draw as large as possible. If you are told to draw, do not write any words on your paper or you will spoil your part of the experiment. If you are told to write, do not draw or you will spoil your part of the experiment. You will have twenty minutes to complete your work.

Those of you that are to draw will have two work sheets. The first page of your work is for drawing what the materials looked like before the experiment began. The second sheet of your work is for drawing answers to "What happened?" and "Why?"

If you forget what to do, read these instructions again. You may leave your seat if you need to look more closely at the experiment when I have finished showing it to you, but you must not disturb anyone else.

When you finish your work, please place it face down on your desk and wait for everyone else to finish. If you finish your work before everyone else is finished, you may read quietly while you wait.

Crystals

Materials for Growing Crystals in the Classroom:

4 jars (250 ml.) with spouts at the bottom for draining the jar
2 rubber bases to fit jar spout
2 clamps for rubber bases
1 gal. distilled water
crystals of green nickel nitrate (see belwo)
crystals of pink cobalt chloride (see below)
hot plate
2-qt. sauce pan
grid for hot plate
2 chemical thermometers (Weston, 0-220F)
scissors
colored pencils (white, true green, violet)
rubber gloves
newspapers
funnel to fill jars
hot pads
2 corks to fit tops of jars
towel
bottle brush to clean jars
2 qt. jars (1 to hold water, 1 to catch solium silicate in after use)
sodium silicate (from a "magic rocks" kit)

drawing pencils:
    Eagle Prisma color turquoise violet 932
    Eagle Prisma color white 938
    Eagle Prisma color true green 910
    Dixon blue 376
    soft lead 1381, No. 2
    Venus col-erase carmine red 1277
    Eagle verithin canary yellow 735

2 (3" diameter) red cardboard circles placed under the thermometers
1 graduated cylinder, 50 ml.
box in which to carry supplies

Materials for Making Original Nickel Nitrate and Cobalt Chloride Crystals:

nickel nitrate or cobalt chloride

plastic tubing that will withstand 200^0. The tubing should be 1.75" long, allowing ¼" for cork, 3/4" for filling 3/4" cut in a spiral shape for removing the crystal. Diameter of tubing is ¼".

corks

glass plunger to fit plastic tubing 4" X ¼" diameter

oven

refrigerator

scotch tape

2 dishes

spoon

2 Mason jars (½ pt.) with tight lids

glass tube with tight cork (small)

cork screws

knife

small corked jars for chemicals: ½" diameter X 1½" long

Making nickel nitrate crystals:

Cork the end of the plastic tubing that is not cut into a spiral. Place scotch tape over the spiral opening to securely close it. Place the nickel nitrate in a dish. With the glass plunger, break up any large piece of nickel nitrate until the crystals are a little larger than sugar crystals. Using the spoon and the glass plunger, fill the plastic tubing a little over 3/4" with the nickel nitrate. Take out just a bit of nickel nitrate at a time because it is highly deliquescent, rapidly becoming liquid if exposed to any per cent of humidity in the atmosphere. Place the plastic tube filled with nickel nitrate upright on a dish in an oven set at 200^o. Leave until the nickel nitrate becomes liquid - about half an hour. Remove the nickel nitrate solution from the oven and place the tube upright in a half-pint Mason jar and close the jar tightly. DO THIS AS RAPIDLY AS POSSIBLE. Place in the refrigerator for two hours. This will solidify the nickel nitrate. Remove the nickel nitrate from the refrigerator and from the jar. Remove the cork from the plastic tubing. If the cork breaks, use a cork screw and scrape off all the cork with a knife. Remove the scotch tape from the spiral end of the tube. Take the glass plunger and force the nickel nitrate from the tube. Trim the crystal at the ends with a knife if it is not even. Immediately place in a very small jar and cork it tightly. As an extra precaution against moisture, place the corked jar in a half-pint Mason jar and tightly close the lid

Making cobalt chloride crystals:

Cobalt chloride sticks too firmly to the tube if done as above. Mix the cobalt chloride with a half honey - half water solution to serve as a binder for the cobalt chloride. Mold in the tube and remove as was the nickel nitrate. DO THIS AS RAPIDLY AS POSSIBLE, and seal in moisture-proof vials and Mason jar as before. Cobalt chloride also is highly deliquescent.

Expression I

Before calling the attention of the class to the experiment, get hot water and place materials on a table where they can be arranged for all to see. Then begin the demonstration. Fill pan half full with hot water and place on hot plate. Fill the 250 ml. jars (with spouts) with sodium silicate solution. Place one jar in the pan which contains 1 qt. of hot water. Insert a thermometer in the mouth of the jar. Place the second jar on the table, inserting the other thermometer in its mouth. This thermometer will register about 70^{o}, or room temperature. Then read general instructions and pass out materials. Pass down aisles and let each child observe crystals in the vials. Remove second jar from pan of hot water at 170^{o} and place on the table in front of the hot plate. Drop one crystal (green) in each jar at the same instant. Re-insert thermometer in each jar after dropping in the crystal. If the crystal falls in a poor place, place it where it can be easily seen by using the thermometer to carefully push it. Allow crystals to grow ten minutes. (The crystal at higher temperature grows more rapidly.) Remove clamp at jar spouts and drain off the sodium silicate solution. Leave the thermometer in but remove it while draining the jars. Replace clamp. Place jars as before. Then have children write or draw. While the children are working, prepare the papers in proper writing and drawing group for Expression II. Also the children may observe the crystals silently (no gestures) and leave their seats to do so during Expression I.

Take up papers for Expression I and distribute the papers for Expression II. Taking up the papers is most efficiently done if the children pass the papers to the front of each row, having the person in front of each row hold the papers. E picks up the papers exchanging them for Expression II papers.

Expression II

At Home:

Prepare cobalt chloride in the same manner as the nickel nitrate, i.e., into a crystal of ¼" diameter and 3/4" long. Grow a set of crystals, one at 70° and the other at 170° for ten minutes in a Mason jar. Remove sodium silicate solution. Replace the sodium silicate solution with distilled water. Do not use tap water because the pH of the tap water is not neutral and causes the silica gel of the crystal to dissolve, producing a clear jelly-like substance in the water. Add a pinch of copper sulphate as a preservative. Seal tightly.

At School:

Distribute papers for second expression. In doing this, be sure that half of the group who wrote on the first expression writes again, and the other half draws. The half of the group that drew on the first expression should draw again and the other half should write.

Show the children the two jars with the silicate formations of the cobalt chloride. Tell them these were grown at home in the same way they saw the green crystals grown in the classroom a little while ago. Place the crystal grown at 170° in front of the hot plate, the other crystal grown at 70° aside on the table. Have the children come by rows and observe the crystals without talking. Then tell them to turn the page of their instructions and answer the questions. Again they may observe the crystals during the expression if they are silent and make no gestures. Take up papers.

Review your check list in the lid of your crayon box to be sure you have packed up all materials before leaving.

Time Schedule

Setting jars in hot water to heat	5 minutes
Instructions and distributing materials (sodium silicate is heating)	10 minutes
Placing jars on heating pads (also may have to wait for 170° jar to heat) showing crystals individually to children, then dropping crystals into sodium silicate solution	5 minutes
Observe crystals grow	10 minutes
Observation after crystals are grown	5 minutes
Expression I	20 minutes
Taking up Expression I papers and distributing papers for Expression II	5 minutes
Instructions and observation for Exp. II	10 minutes
Expression II	20 minutes
Taking up papers and crayons	5 minutes
	1 hr. 35 minutes - Total
Time for explanation afterwards (Friday only)	10 minutes

Electromagnets

Materials:

4 electromagnets, "U" form - #789
Wabash Instruments & Specialities, Inc.
P.O. Box 195, Wabash, Indiana

6 1½V Eveready Batteries, No. 6 painted painted dark blue

3 6V Eveready Latern Batteries, painted red

4 knife switches

4 light sockets, Eagle No. 303
ABC Supply Co.
465 Glenn S.W.
Atlanta, Georgia

4 light bülbs, GE No. 965

10 ft. coil of metal strap with ¼" perforation to attach batteries to board

2 25 ft. rolls of black bell wire

4 boards painted white, 12" X 14"

4 dark blue hand towels

1 screw driver

10 metal weights, 3/4" X 3/4" X 12" square key stock, painted medium brown

11 masking tape, painted brown, placed in lengths needed on contac paper or wax paper

4 rheostats to control temperature and humidity variables

Crayola crayons:
golden rod
yellow
yellow orange
orange yellow
brown
red
orange red
black
white
silver
copper
blue
midnight blue

Materials: (con'd)

Two pairs of electromagnets were constructed and mounted in similar fashion on the boards, with the batteries placed on the back of the boards, a light to one side, the knife switch to the other side, and the electromagnet wired to operate freely in the center of the front of the board.

The pair of electromagnets used for the first experiment had one red 6V battery on one board and two red 6V batteries on the other board. In all other respects they were identical. The weights used were 4 bars taped together and 8 bars taped together.

The pair of electromagnets used for the second demonstration had two blue 1½V batteries on one board and four blue 1½V batteries attached to the other board. The weights used were 2 bars taped together and 4 bars taped together. The weights and tape were painted brown. The arrangements and the weight of the bars were such that: for 2 bars it took 3V to pick them up; for 4 bars it took 6V to pick them up; and for 8 bars it took 12V to pick them up. Thus, for example, in the first demonstration, the one battery could lift the 4 bar block but not the 8 bar block, whereas the 2 batteries could pick up either.

The humidity in this locale varies considerably within short intervals of time, apparently causing a corresponding variance in the strength of the electromagnet. Low humidity results in a stronger electromagnet, while high humidity produces a weaker field. Temperature also affects the magnet's strength, cooler temperature producing stronger fields. For these reasons, the instrument had to be tested prior to use each time and the rheostat adjusted to pick u the bars effectively.

Expression I

Read general instructions, if this has not been done by another experimenter prior to your experiment. If this has been done, introduce yourself and tell the children they are again to observe an experiment and answer the questions "What happened?" and "Why?" Again there can be no talking until both parts of the experiment are completed. Pass out papers and crayons and read the instructions on the papers to the children. Then demonstrate the 6V and 12V electromagnets. The electromagnet needs some warm-up time. Cut it on just prior to arranging the children in a circle. Leave it uncovered.

Have the children arranged in a circle around you, so all can see well. Do this one row at a time until all are in a circle. Then demonstrate each electromagnet three times, showing that the 6V electromagnet will pick up the lighter weight, but not the heavier one and that the 12V electromagnet will pick up both weights. Cut off the electricity and show the magnet does not pick up any weights now. Have the children return silently to their seats. Tell them to turn the first page of their paper and begin Expression I. Tell them they have 20 minutes to complete their work. Leave the electromagnets uncovered, also the weights in full view. The children can come forward and observe the materials silently (no gesture either during Expression I). The children may pick up the weights. Take up papers. While the children are working on Expression I, prepare the papers in the proper writing and drawing groups for Expression II. Take up papers for Expression I and distribute papers for Expression II. Taking up papers is most efficiently done if the children pass the papers to the front of each row, having the person in front of the row hold the papers. E picks up these papers, exchanging them for Expression II papers.

Expression II

Go over instructions with class saying, "Again I will show you the experiment before telling you whether to write or draw. Again you will have 20 minutes for your work. Watch closely. Think, 'What happens? Why does it happen?'"

Arrange the children in a circle around you as before, calling them up one row at a time. Do the warm up of the electromagnets as before. The light is on. Display the second set of electromagnets, but do not demonstrate the magnet picking up the weights. Cut off the lights just prior to having the children return silently to their seats. Tell them to turn the first page of their paper over and begin Expression II. Again they have 20 minutes. Leave the electromagnets and bars uncovered and in plain sight. Again the children may return silently to look at the electromagnets (no gestures), during Expression II. Take up papers. Do not explain the electromagnet nor answer any questions. Do not explain why they were in writing and drawing groups. If asked, tell them a letter answering this will be sent to them after the experiment. Ask the children not to talk about any of the three experiments until all are completed. A complete explanation will be given them at that time.

Time Schedule

	Time
Introduction	10 minutes
Passing out paper and crayons	5 minutes
Demonstrating electromagnet	10 minutes
Expression I	20 minutes
Taking up Exp. I papers and distributing papers for Exp. II	5 minutes
Instructions and observation for Exp. II	10 minutes
Expression II	20 minutes
Taking up papers and crayons	5 minutes
	1 hr. 25 minutes - Total
Time for explanation afterwards (Friday only)	10 minutes

Light Sensitive Papers

Materials:

2 grams silver nitrate ($AgNO_3$) in a small jar
2 sheets of white construction paper
1 small paint brush
rubber gloves
old newspaper
24 ml. water in a small jar
scissors
one magazine in which to store papers
4 black wooden blocks approximately 2" X 2", and 3/4" deep; one square, one triangle, one circle, one rectangle
one box to cover construction paper while drying (19" X 12" X 3")
three daylight fluorescent lamps (14W)*. These lamps were gooseneck, painted coppertone. The shade of the lamp was mostly a white translucent plastic, making the light itself very apparent. The lamps were made in Japan, No. 122, price $6.98. They can be purchased at Rich's Department Store, Lenox Square, Atlanta, Georgia.
4 boxes (17" high X 11½" wide covered with contac paper with a peep hole cut in two boxes). This eliminates any light from sources in the classroom.
1 graduated cylinder: 50 ml.
12 crayola crayons, one each in black, white, maize, peace, burnt orange, apricot, raw sienna, yellow, lemmon yellow, blue, blue-green, mellon
2 grams potassium ferricyanide
2 grams ferric ammonium citrate
20 ml. water
masking tape
1 masking tape box covered with white contac paper
2 boards 8" X 11" X ½" covered with white contac paper

The lamps are set up in the boxes in the following manner: one lamp is turned sideways and placed in one box, the two lamps are placed similarly in the other box. The board can easily be placed across the base of the two lamps, but will not balance on one lamp. Place the masking tape box in the box with one lamp to balance the board. Then tape the goosenecks of the lamp with masking tape so that the lights are stationary 3" above the board. (Do this before entering the classroom and check it upon arrival.) Tape the one lamp a little higher than the two lamps but not noticeably so this will not be given as a reason by S's. This will increase the difference in color between the papers and save a little time.

* Four schools had one lamp with 200W bulb, one lamp with 60W bulb. These lamps were replaced by the daylight lamps because of the heat and glare they produced.

Expression I

Set up lamps and boxes prior to beginning Expression I while the class continues working with the classroom teacher. After introducing oneself, prepare the light sensitive paper before the class.

Walk down the aisles showing each child the silver nitrate crystals in the glass jar. Returning to the front of the class, add water to the crystals, stirring to form a clear solution. Place a sheet of construction paper on a spread-out newspaper in a poorly lighted place. Put on rubber gloves as the silver nitrate solution stains the hands. Paint the construction paper with the solution. Say, "Notice I cover all the paper." The wet paper remains white. The paper is now relatively light sensitive and needs protection from the light, so place a box over it while drying. While the paper is drying, the instructions are read to the class and materials are passed out. Then the prepared paper is cut in half. One half a sheet is taped to each white board. A tri-angle is placed on one which is then placed in a box with one lamp. A square is placed on the other half which is placed in a box with two lamps. The lamps are placed 4" above the paper. The paper under the stronger illumination turns a deeper purple pink than the paper under the dimmer illumination. Let the children come by rows twice to observe the changing papers. This takes ten minutes. Then cut off the lights, remove the black square and triangle and allow the children to observe the papers by rows again. Have the children return silently to their seats, turn to the first page of their answer sheets and begin Expression I. While the children are working on Expression I, prepare the papers in the proper writing and drawing groups for Expression II.

Take up Expression I papers, exchanging them for Expression II papers.

NOTE: Pure silver nitrate ($AgNO_3$) should be kept in a brown bottle, as it readily decomposes with exposure to light. Soluble in tap water, it reacts to form silver chloride ($AgCl$), which is a white, insoluble, light-sensitive substance used extensively in photography. With exposure to light, the silver chloride solution will assume a purplish hue.

Heat will also affect the silver nitrate, causing a reaction which will turn it into a dark brown color.

At first, a few of the children stated that heat and light, or just heat, was the agent when the 200W and 60W bulbs were used. They were correct in this assumption, as the 200W bulb gave off considerable heat as well as light. Therefore, the daylight lamps which give off little heat were substituted. Too, they were easier on the eyes than the bulbs.

Expression II

Materials:

2 grams potassium ferricyanide (green)
10 ml. water

2 grams ferric ammonium citrate (purple)
10 ml. water

1 circle
1 long rectangle

At home, prepare the above solutions separately.

Then mix and paint on white construction paper in poor light.

Dry in a dark place. Hang the paper on a hanger with clothes pins. (The paper is then yellow. When exposed to light it turns green, then blue to deep blue, the shade being determined by the amount of light. When washed to set it, the part exposed to light turns royal blue and the part shielded from light turns white.) There was also a lighter blue shadow effect with our blacks.

Expose half this paper at home to sunlight with a black circle on it and half to plain daylight with a black rectangle on it.

Wash it to set it when clear differences in the two are noticeable. This can be done under the lamps, but it is easier to use the above method.

In class for second expression:

After distributing papers, remind the children to remain silent until the end of the experiment. Turn on the lights in the boxes as for first expression. Show them a white paper for how the papers looked before the experiment began. Show children the two papers prepared at home, telling them these papers were prepared at home under similar conditons to the papers they have just seen. Tell them also that the papers have been fixed so that they will not change any more now. Place each paper under the appropriate light and let the children come by row to look at them more closely. Lift the block and replace it three times correctly in its outline on the paper. Then they are to return to their seats and follow the cinstructions for writing and drawing again. Again they have 20 minutes. Collect papers and materials. Thank the class and teachers and if you are returning, say so before leaving.

Time Schedule

	Time
Preparation of paper	10 minutes
Instructions and distributing materials (paper is drying)	10 minutes
Demonstration	10-15 minutes
Expression I	20 minutes
Taking up Exp. I papers and distributing papers for Exp. II	5 minutes
Instructions & observation for Expression II	10 minutes
Expression II	20 minutes
Taking up papers and crayons	5 minutes
	1 hr. 35 minutes - Total
Time for explanation (Friday only)	10 minutes

Explanation of the Experiments Given to the Children

Immediately after the third and final session in a class, i.e., after the Friday experiment, E explained all three experiments to the children, beginning with the one just completed. E asked the children, "What happened in the experiment you just saw?"

The following statements were given to the experimenters in different forms to suggest several approaches to choose from when talking to the children:

1. The first paper was the one painted with the solution made from the silver nitrate crystals. The film in your camera is coated with similar solutions. The more light the film or paper receives, the darker it turns and this is, in part, how the film in your camera makes a picture, or image.

   The second paper is blueprint paper. It, too, changes color when exposed to light. This is used to make blue prints or drawings of the plans for building houses or building.

2. When happened? One magnet picked up more iron bars than the other. Why? Because of the electricity. Again, the amount of electricity made a difference in how many bars the magnet could pick up. The first pair of magnets you saw had one red battery (6V) for the electricity for one magnet and two red batteries (12V) for the electricity for the other magnet. The magnet with two batteries picked up all six iron bars, but the magnet with only one battery picked up only three iron bars. For the second set of magnets: Two blue batteries (1½V each) would pick up only one iron bar, but four blue batteries (1½V each or 6V) would pick up two iron bars.

3. In the case of the crystals, the amount of heat caused the crystals to grow different sizes. The solution in the jar was sodium silicate in combination with either nickel nitrate or cobalt chloride. The hottest solution (170°) grew the largest green crystals (nickel nitrate). The solution at 70° caused the crystal to grow more slowly and this crystal was the smallest one.

The same thing happened at home with the purplish-pink crystals (cobalt chloride). The crystal grown with the most heat (170°) was larger than the crystal grown with the least amount of heat (70°).

If the children ask for further information, they can be told that the green nickel nitrate crystals combined with the sodium silicate to grow long green pinnacles of silica gel. Add that the chemistry is too complicated to explain until they know more chemistry, but it is not unlike what happens when one makes jello in a refrigerator.

4. So you have seen three things called agents that cause change: heat, light, and electricity. More heat caused longer green pinnacles. Less heat caused shorter green pinnacles. More light caused the color to change more, that is, to a deeper color than did less light. The electromagnet that had more batteries, therefore, more electricity, could pick up more bars than the electromagnet that had fewer batteries, or, electricity.

5, There is much more for you to learn about heat, light and electricity. I hope you will enjoy studying more about them in science this year.

Write these groups on the board:

First:	Write	Draw	Draw	Write
Second:	Write	Draw	Write	Draw

Tell the children that some of them wrote twice or drew twice. Others of them changed from writing to drawing or from drawing to writing. We believe it is easier to do the same thing twice then to change from writing to drawing or from drawing to writing.

APPENDIX B

Instructions for Scoring

Appendix B

Instructions for Scoring

Scorers used the following criteria for scoring
both the written and drawn protocols

Papers

A. CE Score (Range 0-2)

1 pt. (a) Light or heat caused the papers to change color.

2 pts. (b) The amount of light or heat varied, the greater amount causing the greater change in the color of the paper. (In the first expression, the papers turned from pinkish brown to rose brown. A wooden triangle was placed on the white paper under one lamp and a square on the other paper under two lamps. In the second experiment, the papers turned blue and had a shadow on them. A differently shaped triangle from the first experiment was used for the lesser light, and a rectangle was used for the greater light. The greater the amount of light, the deeper the shade of blue.

B. D Score (Range 0-4)

1 pt. (a) The papers change color or curl up.
2 pts. (b) The papers are different shades of the color.

1 pt. (c) Light or heat is present.
2 pts. (d) The amount of light and/or heat varies.

Crystals

A. CE Score (Range 0-2)

1 pt. (a) Heat causes the crystals to grow (or, change in shape as they melted, grew taller, fuzzier, mossier, etc.).

2 pts. (b) One crystal had a hotter solution than the other. The crystal that had the hottest solution grew the most (or, grew taller, fuzzier, mossier, developed bigger "mountain peaks", or was "pulled up", or dissolved).

B. D Score (Range 0-4)

1 pt. (a) Crystals grew.
2 pts. (b) One crystal grew larger than the other.

1 pt. (c) Heat or cold is present.
2 pts. (d) The solution in one jar was hotter than the other.

Magnets

A. CE Score (Range 0-2)

1 pt. (a) Electricity causes the magnet to pick up the bars or, electricity makes the light go on.

2 pts. (b) The greater the amount of electricity, the greater the magnet's strength, or, the brighter the light. The magnet attached to more batteries can pick up more bars, but the magnet attached to fewer batteries picks up fewer bars. (The batteries for the first experiment were 6V, painted red. One magnet was attached to one battery, the other magnet was attached to two batteries. For the second experiment, the batteries were 1½V, painted blue. One magnet was attached to two batteries, the other magnet was attached to four batteries). Credit was given for the following replies: stronger versus weaker, more energy, more power, more magnetism, electricity, more batteries, more dry cells, more force, more tanks or red or blue boxes as the case may be, more rays, or because of more or less lights (lights were, in some cases, believed to be the source of the magnetic energy instead of the dry cells). No credit was given if a reply stated merely that the magnet picks up the bars.

B. D Score (Range 0-6)

1 pt. (a) There are batteries present.
2 pts. (b) The batteries are different in number.

1 pt. (c) There are bars present.
2 pts. (d) The number of bars is different (First experiment: the bars are grouped 3 and 6; Second experiment: the bars are grouped 2 and 4).

1 pt. (e) The light is on.
2 pts. (f) The brightness of the light differs (one light is brighter than the other).

APPENDIX C

Tables 14-53

Table 14
CE Scores for Subjects
For Whom Data Are Incomplete

	First Experiment				Second Experiment				Third Experiment			
School	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
CMP1	DD	2	0	-2	DD	2	2	0	DD	1	1	0
		--[1]	--	--	DD	2	2	0	DD	2	2	0
		--	--	--	DW	1	2	1	DW	2	1	-1
		x[2]	x	x	WW	2	2	0	DD	2	2	0
						0	1	1		1	1	0
		x	x	x	DD	1	1	0	WW	1	1	0
CMP2		--	--	--	WD	1	1	0	DW	1	0	-1
						1	2	1		1	0	-1
		--	--	--	DW	1	1	0	WD	0	0	0
						2	1	-1		1	1	0
	WD	0	0	0	WW	1	1	0		x	x	x
	DW	1	0	-1		x	x	x	WW	2	0	-2
		x	x	x	DW	1	0	-1	WD	1	1	0
		x	x	x	WW	1	1	0		x	x	x
CPM1	DD	0	0	0		--	--	--	DW	2	0	-2
		--	--	--	WD	2	0	-2	DW	1	2	1
	WW	0	0	0		--	--	--	WD	2	2	0
	WD	0	0	0		--	--	--	DD	1	1	0
		--	--	--	DW	1	0	-1		--	--	--
		--	--	--		--	--	--	DW	2	2	0
	WD	1	0	-1		x	x	x	WW	1	1	0
		x	x	x	DW	1	1	0	WW	1	1	0
						1	0	-1		0	0	0
		x	x	x	WD	0	1	1	DW	1	0	-1
		x	x	x	WW	1	1	0	DD	1	1	0
						1	2	1		1	2	1
						0	0	0		2	2	0
CPM2		x	x	x	WD	0	0	0	WW	2	2	0
	WW	1	1	0	DW	1	2	1		x	x	x
		x	x	x	WW	1	1	0		x	x	x
	WD	2	0	-2	WW	1	1	0	DW	2	1	-1

Table 14 (Continued)

	First Experiment				Second Experiment				Third Experiment			
School	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
PMC2		x	x	x	WW	1	1	0	WW	1	1	0
		x	x	x	DW	1	1	0		x	x	x
	DD	0	1	1		--	--	--	WW	1	1	0
	DW	1	0	-1		--	--	--	WD	0	0	0
PCM1	WW	1	2	1		x	x	x	DD	1	2	1
		x	x	x	WD	0	0	0	WW	2	2	0
						2	2	0		2	2	0
		x	x	x	DW	0	1	1	DD	2	2	0
		x	x	x	WW	2	2	0	DW	2	2	0
	DD	0	0	0		x	x	x	WW	1	0	-1
		x	x	x		x	x	x	WD	1	2	1
PCM2		x	x	x	WW	2	2	0	WD	2	1	-1
	DW	1	2	1		x	x	x	WW	1	1	0

1 This symbol means subject was absent for that experiment.

2 This symbol means that subject's response was not scorable (in most cases S both wrote and drew).

Table 14 (Continued)

	First Experiment				Second Experiment				Third Experiment			
School	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
MPC1		x	x	x	DD	1	1	0	WW	1	1	0
		x	x	x	WD	1	2	1	DW	1	0	-1
	WD	0	1	1	DW	2	1	-1	WD	1	0	-1
MPC2	WW	2	2	0		x	x	x	WD	2	1	-1
		0	0	0						1	1	0
		x	x	x	WW	1	1	0	DD	1	1	0
		x	x	x	WD	1	2	1	DW	2	0	-2
MCP1	DW	1	0	-1		--	--	--		--	--	--
		x	x	x	WW	2	0	-2	WD	1	1	0
		--	--	--	WD	1	0	-1	DD	1	1	0
		x	x	x	DW	1	0	-1	WW	0	1	1
	DD	2	2	0		x	x	x	WW	1	0	-1
		--	--	--	WW	2	2	0	WD	1	1	0
MCP2	WW	2	0	-2		x	x	x	WD	1	1	0
		x	x	x		x	x	x	WW	1	1	0
	DD	2	1	-1		x	x	x	DW	2	1	-1
		x	x	x	WD	1	1	0	DW	0	0	0
						1	0	-1		1	1	0
		x	x	x	WW	0	0	0	DD	1	1	0
	WD	2	2	0	DW	2	1	-1	WW	1	1	0
PMC1	WW	2	1	-1	WW	1	1	0	WW	1	1	0
		1	1	0		1	1	0		1	1	0
		1	0	-1		1	1	0		2	1	-1
	DD	0	1	1	WW	1	1	0		--	--	--
		--	--	--		--	--	--	WW	1	0	-1
		x	x	x	WW	1	2	1	DW	2	2	0
						1	2	1		0	0	0
						1	1	0		2	2	0
	WW	0	0	0		x	x	x	WD	2	0	-2
		x	x	x		x	x	x	WW	2	2	0
		x	x	x	WD	1	1	0	DD	2	1	-1

*

Table 15

D Scores for Subjects

For Whom Data Are Incomplete

	First Experiment				Second Experiment				Third Experiment			
School	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
CMP1	DD	4	2	-2	DD	5	4	-1	DD	2	2	0
		--[1]	--	--	DD	6	6	0	DD	4	4	0
		--	--	--	DW	5	6	1	DW	4	2	-2
		x[2]	x	x	WW	4	4	0	DD	4	4	0
						2	2	0		3	3	0
		x	x	x	DD	3	3	0	WW	2	2	0
CMP2		--	--	--	DW	5	2	-3	WD	2	1	-1
						4	4	0		2	3	1
		--	--	--	WD	3	4	1	DW	1	0	-1
						4	3	-1		2	2	0
	WD	1	2	1	WW	3	3	0		x	x	x
	DW	3	1	-2		x	x	x	WW	4	1	-3
		x	x	x	DW	3	1	-2	WD	3	3	0
		x	x	x	WW	4	3	-1		x	x	x
CPM1	DD	1	2	1		--	--	--	DW	4	3	-1
		--	--	--	WD	4	1	-3	DW	3	4	1
	WW	2	2	0		--	--	--	WD	5	5	0
	WD	2	2	0		--	--	--	DD	5	6	1
		--	--	--	DW	2	1	-1		--	--	--
		--	--	--		--	--	--	DW	6	4	-2
	WD	2	2	0		x	x	x	WW	2	2	0
		x	x	x	DW	1	2	1	WW	2	2	0
						4	1	-3		1	1	0
		x	x	x	WD	1	2	1	DW	4	1	-3
		x	x	x	WW	3	3	0	DD	2	2	0
						3	4	1		4	6	2
						1	1	0		5	6	1
CPM2		x	x	x	WD	1	0	-1	WW	4	4	0
	WW	2	4	2	DW	2	4	2		x	x	x
		x	x	x	WW	2	2	0		x	x	x
	WD	4	1	-3	WW	2	3	1	DW	6	2	-4

Table 15 (Continued)

	First Experiment				Second Experiment				Third Experiment			
School	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
PMC2		x	x	x	WW	2	1	-1	WW	2	2	0
		x	x	x	DW	4	2	-2		x	x	x
	DD	3	3	0		--	--	--	WW	2	2	0
	DW	4	1	-3		--	--	--	WD	1	2	1
PCM1	WW	2	4	2		x	x	x	DD	4	4	0
		x	x	x	WD	1	2	1	WW	4	4	0
						4	4	0		4	4	0
		x	x	x	DW	2	2	0	DD	6	6	0
		x	x	x	WW	4	4	0	DW	5	4	-1
	DD	1	1	0		x	x	x	WW	3	3	0
		x	x	x		x	x	x	WD	2	4	2
PCM2		x	x	x	WW	4	6	2	WD	6	5	-1
	DW	2	4	2		x	x	x	WW	2	2	0

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[1] This symbol means subject was absent for that experiment.

[2] This symbol means that subject's response was not scorable (in most cases S both wrote and drew).

Table 15 (Continued)

	First Experiment				Second Experiment				Third Experiment			
School	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
MPC1		x	x	x	DD	3	3	0	WW	2	2	0
		x	x	x	WD	3	4	1	DW	2	1	-1
	WD	2	4	2	DW	4	2	-2	WD	2	1	-1
MPC2	WW	4	4	0		x	x	x	WD	4	3	-1
		3	3	0						2	3	1
		x	x	x	WW	2	2	0	DD	3	3	0
		x	x	x	WD	3	4	1	DW	4	1	-3
MCP1	DW	4	2	-2		--	--	--		--	--	--
		x	x	x	WW	4	1	-3	WD	2	2	0
		--	--	--	WD	2	1	-1	DD	2	2	0
		x	x	x	DW	2	1	-1	WW	1	2	1
	DD	6	6	0		x	x	x	WW	2	1	-1
		--	--	--	WW	4	4	0	WD	3	3	0
MCP2	WW	4	2	-2		x	x	x	WD	2	2	0
		x	x	x		x	x	x	WW	2	2	0
	DD	5	4	-1		x	x	x	DW	4	2	-2
		x	x	x	WD	2	3	-1	DW	0	0	0
						2	1	-1		2	2	0
		x	x	x	WW	0	0	0	DD	3	3	0
						4	4	0		4	4	0
	WD	4	5	1	DW	4	3	-1	WW	3	2	-1
PMC1	WW	4	2	-2	WW	2	2	0	WW	2	2	0
		2	2	0		2	2	0		2	2	0
		2	1	-1		2	3	1		4	2	-2
	DD	1	2	1	WW	2	2	0		--	--	--
		--	--	--		--	--	--	WW	2	1	-1
		x	x	x	WW	2	4	2	DW	4	4	0
						2	4	2		3	1	-2
						2	2	0		4	4	0
	WW	0	0	0		x	x	x	WD	4	2	-2
		x	x	x		x	x	x	WW	4	4	0
		x	x	x	WD	2	3	1	DD	4	2	-2

Table 16
R, S, and R-S Cause-Effect Scores by Materials

	Crystals			Magnets			Papers		
School	R	S	R-S	R	S	R-S	R	S	R-S
CMP1	5.48	4.67	0.81	5.83	5.88	-0.05	6.00	6.33	-0.33
CMP2	5.20	4.75	0.45	6.70	5.83	0.87	5.58	5.20	0.38
CPM1	5.29	5.71	-0.42	6.31	5.93	0.38	5.57	5.50	0.07
CPM2	4.90	4.54	0.36	6.00	5.90	0.10	5.66	5.50	0.16
MPC1	5.24	4.33	0.91	5.58	5.76	-0.18	6.57	5.83	0.74
MPC2	5.61	4.80	0.81	6.45	5.36	1.09	5.11	5.55	-0.44
MCP1	4.53	4.38	0.15	5.83	6.31	-0.48	6.00	5.47	0.53
MCP2	5.17	5.12	0.05	6.00	5.83	0.17	5.43	6.16	-0.73
PMC1	5.12	4.30	0.82	6.14	6.05	0.09	5.80	5.89	-0.09
PMC2	5.89	5.62	0.27	6.45	6.09	0.36	6.24E	5.96E	0.28
PCM1	4.93	5.17	-0.24	6.17	6.20	-0.03	6.00	4.83	1.17
PCM2	4.75	4.28	0.47	6.25	5.40	0.85	5.38E	5.10E	0.28
Treat by Materials	5.18	4.81		6.14	5.88		5.78	5.61	

E = Estimated score

Table 17
R, S, and R-S Cause-Effect Scores by Experiment

	First Experiment			Second Experiment			Third Experiment		
School	R	S	R-S	R	S	R-S	R	S	R-S
CMP1	5.48	4.67	0.81	5.83	5.88	-0.05	6.00	6.33	-0.33
CMP2	5.20	4.75	0.45	6.70	5.83	0.87	5.58	5.20	0.38
CPM1	5.29	5.71	-0.42	5.57	5.50	0.07	6.31	5.93	0.38
CPM2	4.90	4.54	0.36	5.66	5.50	0.16	6.00	5.90	0.10
MPC1	5.58	5.76	-0.18	6.57	5.83	0.74	5.24	4.33	0.91
MPC2	6.45	5.36	1.09	5.11	5.55	-0.44	5.61	4.80	0.81
MCP1	5.83	6.31	-0.48	4.53	4.38	0.15	6.00	5.47	0.53
MCP2	6.00	5.83	0.17	5.17	5.12	0.05	5.43	6.16	-0.73
PMC1	5.80	5.89	-0.09	6.14	6.05	0.09	5.12	4.30	0.82
PMC2	6.24E	5.96E	0.28	6.45	6.09	0.36	5.89	5.62	0.27
PCM1	6.00	4.83	1.17	4.93	5.17	-0.24	6.17	6.20	-0.03
PCM2	5.38E	5.10E	0.28	4.75	4.28	0.47	6.25	5.40	0.85
Treat by Exper.	5.68	5.39		5.62	5.43		5.80	5.47	

E = Estimated score

Table 18
R, S, & R-S Discrimination Scores by Materials

	Crystals			Magnets			Papers		
School	R	S	R-S	R	S	R-S	R	S	R-S
CMP1	9.07	7.84	1.23	9.00	12.07	-3.07	11.00	10.67	0.33
CMP2	8.88	8.25	0.55	10.05	9.73	0.32	9.00	8.20	0.80
CPM1	8.14	9.79	-1.65	10.88	10.21	0.67	8.86	8.83	0.03
CPM2	9.17	8.89	0.28	9.54	9.79	-0.25	9.17	9.40	-0.23
MPC1	9.10	8.25	0.85	10.08	10.10	-0.02	10.69	10.25	0.44
MPC2	9.36	8.10	1.26	10.65	9.25	1.40	8.71	9.27	0.90
MCP1	8.22	9.05	-0.83	9.83	10.56	-0.73	10.17	9.27	0.90
MCP2	8.84	9.12	-0.28	10.00	9.96	0.04	8.81	10.33	-1.52
PMC1	8.59	7.30	1.29	10.04	11.45	-1.41	9.55	9.54	0.01
PMC2	9.83	9.60	0.23	10.90	10.74	0.16	10.35E	10.11E	0.24E
PCM1	8.60	8.17	0.43	11.00	10.40	1.40	9.67	8.07	1.60
PCM2	9.00	8.30	0.70	10.63	7.20	3.43	8.87E	8.63E	0.24E
Treat by Materials	8.90	8.56		10.22	10.12		9.57	9.38	

E = Estimated score

Table 19
R, S, & R-S Discrimination Scores
by Experiment

School	First Experiment R	S	R-S	Second Experiment R	S	R-S	Third Experiment R	S	R-S
CMP1	9.07	7.84	1.23	9.00	12.07	-3.07	11.00	10.67	0.33
CMP2	8.80	8.25	0.55	10.05	9.73	0.32	9.00	8.20	0.80
CPM1	8.14	9.79	-1.65	8.86	8.83	0.03	10.88	10.21	0.67
CPM2	9.17	8.89	0.28	9.17	9.40	-0.23	9.54	9.79	-0.25
MPC1	10.08	10.10	-0.02	10.69	10.25	0.44	9.10	8.25	0.85
MPC2	10.65	9.25	1.40	8.71	9.75	-1.04	9.36	8.10	1.26
MCP1	9.83	10.56	-0.73	8.22	9.05	-0.83	10.17	9.27	0.90
MCP2	10.00	9.96	0.04	8.84	9.12	-0.28	8.81	10.33	-1.52
PMC1	9.55	9.54	0.01	10.04	11.45	-1.41	8.59	7.30	1.29
PMC2	10.35E	10.11E	0.24E	10.90	10.74	0.16	9.83	9.60	0.23
PCM1	9.67	8.07	1.60	8.60	8.17	0.43	11.00	10.40	1.40
PCM2	8.87E	8.63E	0.24E	9.00	8.30	0.70	10.63	7.20	3.43
Treat by Exper.	9.52	9.25		9.34	9.74		9.82	9.11	

E = Estimated score

Table 20
Mean D Change Scores by Materials with Modified Magnet Scores

School	Crystals				Magnets				Papers				School Means
	WW	DD	WD	DW	WW	DD	WD	DW	WW	DD	WD	DW	
CMP1	4.50	4.57	4.67	3.17	4.44	4.89	6.05	4.17	5.50	5.50	6.38	4.29	4.84
CMP2	4.80	4.00	4.25	4.00	5.17	4.87	5.22	4.60	4.50	4.50	4.20	4.00	4.51
CPM1	4.14	4.00	5.50	4.29	5.11	5.48	6.14	4.00	4.43	4.43	4.50	4.33	4.70
CPM2	4.17	5.00	4.29	4.60	4.81	4.89	5.33	4.52	4.57	4.60	5.57	3.83	4.68
MPC1	4.43	4.67	3.50	4.75	5.17	4.89	6.11	4.00	4.83	5.86	5.75	4.50	4.87
MPC2	4.86	4.50	3.50	4.60	5.17	5.27	5.17	4.33	4.00	4.71	5.00	4.75	4.65
MCP1	4.00	4.22	4.38	4.67	5.00	4.89	6.00	4.33	5.17	5.00	5.60	3.67	4.74
MCP2	4.17	4.67	4.83	4.29	4.89	5.11	5.86	4.11	4.14	4.67	5.83	4.50	4.76
PMC1	4.71	3.88	3.80	3.50	4.83	5.19	6.50	4.47	4.80	4.75	5.29	4.25	4.66
PMC2	4.40	5.43	5.00	4.60	5.27	5.33	6.43	4.07	5.06E	5.18E	5.50E	4.53E	5.07
PCM1	4.00	4.60	5.00	3.17	5.00	5.67	5.93	4.33	5.00	4.67	3.67	4.40	4.62
PCM2	5.00	4.00	4.80	3.50	5.00	5.42	4.73	3.40	4.47E	4.60E	4.91E	3.95E	4.48
Treat by Materials	4.43	4.46	4.46	4.10	4.99	5.16	5.79	4.19	4.71	4.87	5.18	4.25	4.72

E = Estimated score

Table 21

Mean D Change Scores by Experiment with Modified Magnet Scores

School	First Experiment WW	DD	WD	DW	Second Experiment WW	DD	WD	DW	Third Experiment WW	DD	WD	DW	School Means
CMP1	4.50	4.57	4.67	3.17	4.44	4.89	6.05	4.17	5.50	5.50	6.38	4.29	4.84
CMP2	4.80	4.00	4.25	4.00	5.17	4.87	5.22	4.60	4.50	4.50	4.20	4.00	4.51
CPM1	4.14	4.00	5.50	4.29	4.43	4.43	4.50	4.33	5.11	5.48	6.14	4.00	4.70
CPM2	4.17	5.00	4.29	4.60	4.57	4.60	5.57	3.83	4.81	4.89	5.33	4.52	4.68
MPC1	5.17	4.89	6.11	4.00	4.83	5.86	5.75	4.50	4.43	4.67	3.50	4.75	4.87
MPC2	5.17	5.27	5.17	4.33	4.00	4.71	5.00	4.75	4.86	4.50	3.50	4.60	4.66
MCP1	5.00	4.89	6.00	4.33	4.00	4.22	4.38	4.67	5.17	5.00	5.60	3.67	4.74
MCP2	4.89	5.11	5.86	4.11	4.17	4.67	4.83	4.29	4.14	4.67	5.83	4.50	4.76
PMC1	4.80	4.75	5.29	4.25	4.83	5.19	6.50	4.47	4.71	3.88	3.80	3.50	4.66
PMC2	5.06E	5.18E	5.50E	4.53E	5.27	5.33	6.43	4.07	4.40	5.43	5.00	4.60	5.07
PCM1	5.00	4.67	3.67	4.40	4.00	4.60	5.00	3.17	5.00	5.67	5.93	4.33	4.62
PCM2	4.47E	4.60E	4.91E	3.95E	5.00	4.00	4.80	3.50	5.00	5.42	4.73	3.40	4.48
Treat by Exper.	4.76	4.74	5.10	4.16	4.56	4.78	5.34	4.20	4.80	4.97	5.00	4.18	4.67

E = Estimated score

Table 22
R, S, & R-S Discrimination Scores by Materials with Modified Magnet Scores

	Crystals			Magnets			Papers		
School	R	S	R-S	R	S	R-S	R	S	R-S
CMP1	9.07	7.84	1.23	9.33	10.22	-0.89	11.00	10.67	0.33
CMP2	8.80	8.25	0.55	10.04	9.82	0.22	9.00	8.20	0.80
CPM1	8.14	9.79	-1.65	10.59	10.14	0.45	8.86	8.83	0.03
CPM2	9.17	8.89	0.28	9.70	9.85	-0.15	9.17	9.40	-0.23
MPC1	9.10	8.25	0.45	10.06	10.11	-0.05	10.69	10.25	0.44
MPC2	9.36	8.10	1.26	10.44	9.50	0.94	8.71	9.75	-1.04
MCP1	8.22	9.05	-0.83	9.89	10.33	-0.44	10.17	9.27	0.90
MCP2	8.84	9.12	-0.28	10.00	9.97	0.03	8.81	10.33	-1.52
PMC1	8.59	7.30	1.29	10.02	10.97	-0.95	9.55	9.54	0.01
PMC2	9.83	9.60	0.23	10.60	10.50	0.10	10.24E	10.03E	0.21E
PCM1	8.60	8.17	0.43	10.67	10.26	0.41	9.67	8.07	1.60
PCM2	9.00	8.30	0.70	10.42	8.13	2.29	9.07E	8.86E	0.21E
Treat by Materials	8.89	8.56		10.15	9.98		9.77	9.58	

E = Estimated score

Table 23
R, S, & R-S Discrimination Scores
by Experiment
with Modified Magnet Scores

School	First Experiment			Second Experiment			Third Experiment		
	R	S	R-S	R	S	R-S	R	S	R-S
CMP1	9.07	7.84	1.23	9.33	10.22	-0.89	11.00	10.67	0.33
CMP2	8.80	8.25	0.55	10.04	9.82	0.22	9.00	8.20	0.80
CPM1	8.14	9.79	-1.65	8.86	8.83	0.03	10.59	10.14	0.45
CPM2	9.17	8.89	0.28	9.17	9.40	-0.23	9.70	9.85	-0.15
MPC1	10.06	10.11	-0.05	10.69	10.25	0.44	9.10	8.25	0.85
MPC2	10.44	9.50	0.94	8.71	9.75	-1.04	9.36	8.10	1.26
MCP1	9.89	10.33	-0.44	8.22	9.05	-0.83	10.17	9.27	0.90
MCP2	10.00	9.97	0.03	8.84	9.12	-0.28	8.81	10.33	-1.52
PMC1	9.55	9.54	0.01	10.02	10.97	-0.95	8.59	7.30	1.29
PMC2	10.24E	10.03E	0.21E	10.60	10.50	0.10	9.83	9.60	0.23
PCM1	9.67	8.07	1.60	8.60	8.17	0.43	10.67	10.26	0.41
PCM2	9.07E	8.86E	0.21E	9.00	8.30	0.70	10.42	8.13	2.29
Treat by Exper.	9.51	9.26		9.34	9.53		9.77	9.18	

E = Estimated score

Table 24

R-S Discrimination Scores by Experiment and by Materials with Modified Magnet Scores

School	Experiment First	Second	Third	Materials Crystals	Magnets	Papers	School Means
CMP1	1.23	-0.89	0.33	1.23	-0.89	0.33	0.22
CMP2	0.55	0.22	0.80	0.55	0.22	0.80	0.52
CPM1	-1.65	0.03	0.45	-1.65	0.45	0.03	-0.39
CPM2	0.28	-0.23	-0.15	0.28	-0.15	-0.23	-0.03
MPC1	-0.05	0.44	0.85	0.85	-0.05	0.44	0.41
MPC2	0.94	-1.04	1.26	1.26	0.94	-1.04	0.39
MCP1	-0.44	-0.83	0.90	-0.83	-0.44	0.90	-0.12
MCP2	0.03	-0.28	-1.52	-0.28	0.03	-1.52	-0.59
PMC1	0.01	-0.95	1.29	1.29	-0.95	0.01	0.12
PMC2	0.21E	0.10	0.23	0.23	0.10	0.21E	0.10
PCM1	1.60	0.43	0.41	0.43	0.41	1.60	0.81
PCM2	0.21E	0.70	2.29	0.70	2.29	0.21 E	1.07
Means	0.24	-0.19	0.60	0.34	0.16	0.14	0.22
s	0.83	0.61	0.92	0.89	0.86	0.83	0.84
t	1.01*	-1.08	2.26	1.32	0.64	0.60*	1.54
p	NS	NS	0.05	NS	NS	NS	NS

E = Estimated Score

*df = 9

Table 25
Analysis of Variance of R-S Differences Among Discrimination Change Scores Based on Modified Magnet Scores

Source of Variance	Sum of Squares	df	Mean Square	F	P
Total	24.7303	35			
Between schools	7.3451	11			
Within schools	17.3852	22			
Materials	0.2734	2	0.1367	0.18	NS
Residual	11.1118	22	0.7778		
Experiment	3.7270	2	1.8635	3.37*	NS
Residual	11.9855	22	0.5448		

* df = 2 and 20

Table 26

Estimation of Missing Cause-Effect Change Scores for PMC2 Papers and PCM2 Papers

School	Crystals				Magnets				Papers				School Means
	WW	DD	WD	DW	WW	DD	WD	DW	WW	DD	WD	DW	
CMP1	2.62	2.86	2.67	2.00	2.83	3.00	3.00	2.88	2.83	3.17	3.62	2.71	2.85
CMP2	2.80	2.40	2.25	2.50	3.50	3.20	2.83	3.00	2.83	2.75	2.40	2.80	2.77
CPM1	2.29	3.00	3.00	2.71	3.17	3.14	3.43	2.50	2.71	2.86	2.50	3.00	2.86
CPM2	2.33	2.57	2.14	2.40	3.00	3.00	2.90	3.00	2.86	2.80	3.00	2.50	2.71
MPC1	2.57	2.67	1.83	2.50	2.75	2.83	3.33	2.43	3.00	3.57	3.00	2.83	2.78
MPC2	2.86	2.75	2.00	2.80	3.25	3.20	2.50	2.86	2.25	2.86	2.80	2.75	2.74
MCP1	2.20	2.33	1.88	2.50	3.00	2.83	3.11	3.20	3.00	3.00	2.80	2.67	2.71
MCP2	2.50	2.67	2.83	2.29	2.83	3.17	3.00	2.83	2.43	3.00	3.33	2.83	2.81
PMC1	3.00	2.12	1.80	2.50	3.00	3.14	3.25	2.80	2.80	3.00	3.14	2.75	2.78
PMC2	2.60	3.29	2.62	3.00	3.20	3.25	3.29	2.80					3.006
PCM1	2.33	2.60	3.00	2.17	3.17	3.00	3.20	3.00	3.00	3.00	1.83	3.00	2.78
PCM2	3.00	1.75	2.40	1.88	3.00	3.25	2.60	2.80					2.585
Sums by Treatment	27.67	28.86	26.97	26.68	33.38	34.03	33.78	31.40	34.46	35.14	32.53	33.11	2.779

$\overline{WW}_{34} = 2.809$ $\overline{DD}_{34} = 2.887$ $\overline{WD}_{34} = 2.743$ $\overline{DW}_{34} = 2.682$

$\overline{I}_{40} = 2.754$ $\overline{II}_{48} = 2.762$ $\overline{III}_{48} = 2.817$

$\overline{C}_{48} = 2.495$ $\overline{M}_{48} = 3.001$ $\overline{P}_{40} = 2.849$

$K_{PCM2} = \underline{3.006 + 2.754 + 2.849 - 3(2.779)}$

PCM2 WW = K + 2.809 = 3.081
PCM2 DD = K + 2.887 = 3.159
PCM2 WD = K + 2.743 = 3.015
PCM2 DW = K + 2.682 = 2.954

$K_{PMC2} = \underline{2.585 + 2.754 + 2.849 - 3(2.779)}$

PMC2 WW = K + 2.809 = 2.654
PMC2 DD = K + 2.887 = 2.732
PMC2 WD = K + 2.743 = 2.583
PMC2 DW = K + 2.682 = 2.524

Table 27

Estimation of Missing Discrimination Change Scores for PMC2 Papers and PCM2 Papers

	Crystals				Magnets				Papers				Scho
School	WW	DD	WD	DW	WW	DD	WD	DW	WW	DD	WD	DW	Mean
CMP1	4.50	4.57	4.67	3.17	4.17	4.83	6.57	3.75	5.50	5.50	6.38	4.29	4.82
CMP2	4.80	4.00	4.20	4.00	5.25	4.80	5.33	4.40	4.50	4.50	4.20	4.00	4.50
CPM1	4.14	4.00	5.50	4.29	5.17	5.71	6.71	3.50	4.43	4.43	4.50	4.33	4.73
CPM2	4.17	5.00	4.29	4.60	4.71	4.83	5.50	4.29	4.57	4.60	5.57	3.83	4.66
MPC1	4.43	4.67	3.50	4.75	5.25	4.83	6.67	3.43	4.83	5.86	5.75	4.5C	4.87
MPC2	4.86	4.50	3.50	4.60	5.25	5.40	5.25	4.00	4.00	4.71	5.00	4.75	4.65
MCP1	4.00	4.22	4.38	4.67	5.00	4.83	6.56	4.00	5.17	5.00	5.60	3.67	4.75
MCP2	4.17	4.67	4.83	4.29	4.83	5.17	6.29	3.67	4.14	4.67	5.83	4.50	4.76
PMC1	4.71	3.88	3.80	3.50	4.75	5.29	7.25	4.20	4.80	4.75	5.29	4.25	4.71
PMC2	4.40	5.43	5.00	4.60	5.40	5.50	7.14	3.60					5.13
PCM1	4.00	4.60	5.00	3.17	5.00	6.00	6.40	4.00	5.00	4.67	3.67	4.40	4.66
PCM2	5.00	4.00	4.80	3.50	5.00	5.63	4.60	2.60					4.39
Sums by Treatment	53.18	53.54	53.47	49.14	59.78	62.82	74.27	45.44	46.94	48.69	51.79	42.52	4.72

$\overline{WW}_{34} = 4.703$ $\overline{DD}_{34} = 4.854$ $\overline{WD}_{34} = 5.280$ $\overline{DW}_{34} = 4.032$

$\overline{I}_{40} = 4.680$ $\overline{II}_{48} = 4.733$ $\overline{III}_{48} = 4.733$

$\overline{C}_{48} = 4.361$ $\overline{M}_{48} = 5.048$ $\overline{P}_{40} = 4.748$

$K_{PCM2} = \underline{4.391 + 4.680 + 4.748 - 3(4.720)}$

PCM2 WW = K + 4.703 = 4.362
PCM2 DD = K + 4.854 = 4.513
PCM2 WD = K + 5.280 = 4.939
PCM2 DW = K + 4.032 = 3.691

$K_{PMC2} = \underline{5.133 + 4.680 + 4.748 - 3(4.720)}$

PMC2 WW = K + 4.703 = 5.104
PMC2 DD = K + 4.854 = 5.255
PMC2 WD = K + 5.280 = 5.681
PMC2 DW = K + 4.032 = 4.433

Table 28

Estimation of Discrimination Change Scores for PMC2 Papers and PCM2 Papers with Modified Magnet Scores

	Crystals				Magnets				Papers				School
School	WW	DD	WD	DW	WW	DD	WD	DW	WW	DD	WD	DW	Means
CMP1	4.50	4.57	4.67	3.17	4.44	4.89	6.05	4.17	5.50	5.50	6.38	4.29	4.84
CMP2	4.80	4.00	4.25	4.00	5.17	4.87	5.22	4.60	4.50	4.50	4.20	4.00	4.51
CPM1	4.14	4.00	5.50	4.29	5.11	5.48	6.14	4.00	4.43	4.43	4.50	4.33	4.70
CPM2	4.17	5.00	4.29	4.60	4.81	4.89	5.33	4.52	4.57	4.60	5.57	3.83	4.68
MPC1	4.43	4.67	3.50	4.75	5.17	4.89	6.11	4.00	4.83	5.86	5.75	4.50	4.87
MPC2	4.86	4.50	3.50	4.60	5.17	5.27	5.17	4.33	4.00	4.71	5.00	4.75	4.66
MCP1	4.00	4.22	4.38	4.67	5.00	4.89	6.00	4.33	5.17	5.00	5.60	3.67	4.74
MCP2	4.17	4.67	4.83	4.29	4.89	5.11	5.86	4.11	4.14	4.67	5.83	4.50	4.76
PMC1	4.71	3.88	3.80	3.50	4.83	5.19	6.50	4.47	4.80	4.75	5.29	4.25	4.66
PMC2	4.40	5.43	5.00	4.60	5.27	5.33	6.43	4.07					5.066
PCM1	4.00	4.60	5.00	3.17	5.00	5.67	5.93	4.33	5.00	4.67	3.67	4.40	4.62
PCM2	5.00	4.00	4.80	3.50	5.00	5.42	4.73	3.40					4.481
Sums by Treatment	53.18	53.54	53.52	49.14	59.86	61.90	69.47	50.33	46.94	48.69	51.79	42.52	4.712

$\overline{WW}_{34} = 4.705$ $\overline{DD}_{34} = 4.827$ $\overline{WD}_{34} = 5.141$ $\overline{DW}_{34} = 4.176$

$\overline{I}_{40} = 4.677$ $\overline{II}_{48} = 4.718$ $\overline{III}_{48} = 4.736$

$\overline{C}_{48} = 4.362$ $\overline{M}_{48} = 5.032$ $\overline{P}_{40} = 4.748$

$K_{PCM2} = \underline{4.481 + 4.677 + 4.748 - 3(4.712)}$

PCM2 WW $= K + 4.705 = 4.475$

PCM2 DD $= K + 4.827 = 4.597$

PCM2 WD $= K + 5.141 = 4.911$

PCM2 DW $= K + 4.176 = 3.946$

$K_{PMC2} = \underline{5.066 + 4.677 + 4.748 - 3(4.712)}$

PMC2 WW $= K + 4.705 = 5.060$

PMC2 DD $= K + 4.827 = 5.182$

PMC2 WD $= K + 5.141 = 5.496$

PMC2 DW $= K + 4.176 = 4.531$

Table 29

Frequency of Positive and Negative CE and D Mean Change Scores by Materials

1. Frequencies of Negative, Zero, and Positive Means

		CE Scores								
		Crystals			Magnets			Papers		
		Neg	0	Pos	Neg	0	Pos	Neg	0	Pos
D Scores	Pos	0	1	1	4	3	16	3	3	8
	0	2	2	0	0	2	1	0	2	0
	Neg	39	3	0	13	6	3	25	6	1

2. Frequencies of Negative and Non-Negative Means

		CE Scores					
		Neg	Non-Neg	Neg	Non-Neg	Neg	Non-Neg
D Scores	Non-Neg	2	4	4	22	3	13
	Neg	39	3	13	9	25	7
χ^2		10.1*		8.1*		17.5**	

*p < .01

**p < .001

Table 30
CMP1 CE Scores

	Crystals First Experiment				Magnets Second Experiment				Papers Third Experiment			
Group	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
A	WW	2	2	0	DW	2	1	-1	WD	1	1	0
		1	0	-1		1	1	0		0	1	1
		2	2	0		2	2	0		1	2	1
		1	1	0		1	1	0		1	1	0
		2	0	-2		2	2	0		1	2	1
		1	1	0		1	0	-1		0	1	1
		1	1	0		2	2	0		0	1	1
		1	1	0		1	2	1		0	0	0
Sum 8		11	8	-3		12	11	-1		4	9	5
B	DD	1	1	0	WD	1	1	0	DW	2	1	-1
		2	2	0		1	1	0		2	2	0
		2	2	0		0	1	1		1	0	-1
		1	1	0		1	1	0		1	1	0
		2	1	-1		2	2	0		1	1	0
		1	1	0		2	1	-1		1	1	0
		0	0	0		1	1	0		0	0	0
Sum 7		9	8	-1		8	8	0		8	6	-2
C	WD	2	2	0	WW	0	0	0	DD	1	2	1
		1	1	0		2	1	-1		0	0	0
		1	0	-1		1	0	-1		1	1	0
		1	1	0		1	1	0		1	1	0
		2	2	0		0	1	1		2	2	0
		2	1	-1		1	1	0		1	1	0
Sum 6		9	7	-2		5	4	-1		6	7	1
D	DW	2	1	-1	DD	1	1	0	WW	1	0	-1
		2	0	-2		2	2	0		0	0	0
		1	1	0		2	2	0		1	1	0
		1	1	0		1	1	0		1	1	0
		1	0	-1		1	1	0		1	1	0
		2	0	-2		1	1	0		1	1	0
Sum 6		9	3	-6		8	8	0		5	4	-1

Table 31
CMP2 CE Scores

	Crystals				Magnets				Papers			
	First Experiment				Second Experiment				Third Experiment			
Group	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
A	WW	0	0	0	DD	2	2	0	DW	1	1	0
		2	2	0		2	2	0		2	2	0
		1	2	1		1	1	0		0	1	1
		2	2	0		2	2	0		2	1	-1
		2	0	-2		1	2	1		1	0	-1
Sum 5		7	6	-1		8	9	1		6	5	-1
B	DD	1	1	0	DW	2	2	0	WD	2	2	0
		1	0	-1		1	2	1		0	0	0
		0	0	0		2	2	0		1	1	0
		1	0	-1		1	1	0		1	0	-1
		1	0	-1		2	1	-1		2	0	-2
Sum 5		4	1	-3		8	8	0		6	3	-3
C	WD	1	0	-1	WW	0	1	1	DD	1	1	0
		0	0	0		2	2	0		2	2	0
		0	0	0		1	1	0		1	1	0
		2	0	-2		0	1	1		2	1	-1
Sum 4		3	0	-3		3	5	2		6	5	-1
D	DW	2	2	0	WD	1	0	-1	WW	2	1	-1
		0	0	0		1	1	0		0	0	0
		1	0	-1		1	2	1		1	1	0
		2	2	0		1	1	0		2	2	0
		2	0	-2		2	1	-1		2	2	0
		0	0	0		1	1	0		1	1	0
Sum 6		7	4	-3		7	6	-1		8	7	-1

Table 32
CPM1 CE Scores

	Crystals First Experiment				Papers Second Experiment				Magnets Third Experiment			
Group	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
		1	1	0		0	0	0		1	1	0
		1	1	0		0	0	0		0	1	1
		2	0	-2		1	0	-1		1	2	1
A	WW	2	0	-2	DD	0	0	0	WD	1	2	1
		1	0	-1		0	0	0		2	2	0
		0	0	0		1	1	0		1	1	0
		1	1	0		1	1	0		1	1	0
Sum 7		8	3	-5		3	2	-1		7	10	3
B	DD	1	1	0	WD	2	1	-1	DW	1	0	-1
		0	0	0		1	1	0		1	1	0
Sum 2		1	1	0		3	2	-1		2	1	-1
		0	1	1		1	1	0		0	0	0
		0	0	0		1	1	0		1	1	0
		2	0	-2		0	1	1		1	1	0
C	WD	0	1	1	DW	1	0	-1	WW	2	2	0
		0	0	0		1	1	0		1	2	1
		0	0	0		1	1	0		2	2	0
Sum 6		2	2	0		5	5	0		7	8	1
		2	2	0		2	2	0		2	1	-1
		1	0	-1		1	1	0		1	1	0
		2	2	0		2	2	0		1	2	1
D	DW	2	2	0	WW	2	1	-1	DD	1	1	0
		0	0	0		0	0	0		1	2	1
		1	1	0		2	1	-1		0	0	0
		1	0	-1		0	0	0		1	1	0
Sum 7		9	7	-2		9	7	-2		7	8	1

Table 33
CPM2 CE Scores

	Crystals				Papers				Magnets			
	First Experiment				Second Experiment				Third Experiment			
Group	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
A	WW	0	0	0	DW	1	1	0	DD	2	2	0
		0	0	0		1	0	-1		1	1	0
		2	0	-2		2	1	-1		2	2	0
		0	0	0		1	1	0		1	1	0
		2	0	-2		2	1	-1		1	1	0
		0	0	0		1	1	0		2	2	0
Sum 6		4	0	-4		8	5	-3		9	9	0
B	DD	0	0	0	WD	1	1	0	WW	1	2	1
		1	2	1		1	1	0		2	2	0
		1	0	-1		1	1	0		2	1	-1
		0	0	0		1	1	0		2	2	0
		1	0	-1		0	0	0		2	2	0
		2	0	-2		0	0	0		1	2	1
		1	1	0		1	1	0		2	1	-1
Sum 7		6	3	-3		5	5	0		12	12	0
C	WD	1	0	-1	WW	2	2	0	DW	1	1	0
		1	0	-1		1	1	0		1	1	0
		1	0	-1		1	0	-1		2	2	0
		2	0	-2		2	2	0		2	2	0
		1	0	-1		0	0	0		2	2	0
		0	0	0		1	1	0		1	1	0
		0	0	0		1	1	0		2	2	0
Sum 7		6	0	-6		8	7	-1		11	11	0
D	DW	1	1	0	DD	1	1	0	WD	2	2	0
		0	1	1		0	0	0		2	2	0
		1	0	-1		1	1	0		2	2	0
		0	0	0		1	1	0		1	1	0
		0	0	0		0	0	0		1	1	0
		1	0	-1		1	1	0		2	1	-1
		2	0	-2		1	1	0		2	2	0
		1	0	-1		1	1	0		1	1	0
		1	0	-1		1	1	0		1	1	0
		1	0	-1		2	0	-2		2	2	0
Sum 10		8	2	-6		9	7	-2		16	15	-1

Table 34
MPC1 CE Scores

	Magnets First Experiment				Papers Second Experiment				Crystals Third Experiment			
Group	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
A	WW	1	1	0	WD	1	1	0	DW	1	1	0
		2	2	0		1	1	0		1	0	-1
		2	1	-1		2	2	0		1	0	-1
		2	2	0		1	1	0		0	0	0
Sum 4		7	6	-1		5	5	0		3	1	-2
B	DD	2	2	0	WW	2	2	0	WD	2	0	-2
		1	1	0		2	2	0		2	1	-1
		2	2	0		2	1	-1		2	2	0
		2	1	-1		0	1	1		0	0	0
		2	2	0		0	0	0		2	0	-2
		1	1	0		1	1	0		2	0	-2
Sum 6		10	9	-1		7	7	0		10	3	-7
C	WD	0	0	0	DW	1	1	0	DD	1	1	0
		1	1	0		1	1	0		1	1	0
		2	2	0		2	2	0		2	2	0
		1	2	1		1	0	-1		1	0	-1
		0	1	1		0	0	0		1	1	0
		1	1	0		1	1	0		1	0	-1
Sum 7		5	7	2		6	5	-1		7	5	-2
D	DW	2	1	-1	DD	0	1	1	WW	1	0	-1
		1	0	-1		0	1	1		0	0	0
		2	0	-2		1	1	0		0	0	0
		2	2	0		1	2	1		1	0	-1
		1	1	0		1	1	0		0	0	0
		1	0	-1		1	1	0		1	1	0
		1	2	1		0	1	1		2	1	-1
Sum 7		10	6	-4		4	8	4		5	2	-3

Table 35
MPC2 CE Scores

		Magnets				Papers				Crystals		
		First Experiment				Second Experiment				Third Experiment		
Group	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
A	WW	1	2	1	DW	1	1	0	WD	2	1	-1
		2	2	0		1	1	0		2	1	-1
		2	2	0		1	1	0		2	2	0
		2	2	0		1	0	-1		2	0	-2
Sum 4		7	8	1		4	3	-1		8	4	-4
B	DD	0	2	2	WD	1	1	0	DW	1	1	0
		2	0	-2		1	1	0		1	1	0
		0	1	1		2	2	0		0	2	2
		1	1	0		2	2	0		2	0	-2
		1	1	0		2	1	-1		2	1	-1
Sum 5		4	5	1		8	7	-1		6	5	-1
C	WD	2	2	0	WW	2	1	-1	DD	1	0	-1
		2	1	-1		1	1	0		1	0	-1
		2	2	0		2	0	-2		1	0	-1
		2	1	-1		0	0	0		0	2	2
Sum 4		8	6	-2		5	2	-3		3	2	-1
D	DW	2	2	0	DD	1	1	0	WW	0	0	0
		1	0	-1		1	1	0		2	1	-1
		1	1	0		1	1	0		1	1	0
		2	2	0		1	1	0		1	1	0
		2	1	-1		2	1	-1		2	2	0
		1	2	1		1	1	0		1	0	-1
		2	2	0		1	1	0		1	2	1
Sum 7		11	10	-1		8	7	-1		8	7	-1

Table 36
MCP1 CE Scores

	Magnets First Experiment				Crystals Second Experiment				Papers Third Experiment			
Group	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
A	WW	2	2	0	WD	1	0	-1	DD	1	1	0
		1	1	0		1	0	-1		1	2	1
		0	0	0		1	1	0		1	1	0
		2	2	0		2	0	-2		1	2	1
		0	0	0		1	1	0		1	1	0
		2	2	0		2	0	-2		2	0	-2
		2	2	0		2	0	-2		2	2	0
		2	2	0		1	0	-1		0	0	0
Sum 8		11	11	0		11	2	-9		9	9	0
B	DD	1	1	0	DW	0	0	0	WW	1	1	0
		2	2	0		1	0	-1		0	0	0
		2	1	-1		2	1	-1		0	0	0
		2	2	0		2	1	-1		0	1	1
		2	2	0		2	2	0		2	2	0
		1	1	0		1	1	0		2	1	-1
Sum 6		10	9	-1		7	4	-3		5	5	0
C	WD	1	2	1	DD	1	0	-1	DW	1	1	0
		1	1	0		1	1	0		1	1	0
		1	1	0		1	0	-1		2	1	-1
		2	1	-1		1	0	-1		0	0	0
		2	2	0		1	0	-1		1	0	-1
		2	1	-1		1	0	-1		1	1	0
		0	2	2		0	0	0		1	0	-1
		1	1	0		1	0	-1		1	1	0
		2	2	0		0	0	0		1	1	0
Sum 9		12	13	1		7	1	-6		9	6	-3
D	DW	1	2	1	WW	0	0	0	WD	1	1	0
		2	2	0		2	0	-2		1	1	0
		1	2	1		2	0	-2		2	1	-1
		1	1	0		0	0	0		1	1	0
		2	1	-1		1	1	0		2	2	0
Sum 5		7	8	1		5	1	-4		7	6	-1

*

Table 37
MCP2 CE Scores

		Magnets First Experiment				Crystals Second Experiment				Papers Third Experiment		
Group	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
A	WW	2	0	-2	DD	1	1	0	WD	0	1	1
		2	2	0		1	0	-1		1	1	0
		1	2	1		2	1	-1		0	2	2
		2	1	-1		1	1	0		1	0	-1
		1	2	1		1	1	0		0	1	1
		1	1	0		2	2	0		2	1	-1
Sum 6		9	8	-1		8	6	-2		4	6	-2
B	DD	1	1	0	WD	1	2	1	DW	1	1	0
		1	1	0		2	2	0		1	1	0
		1	2	1		1	1	0		1	1	0
		1	1	0		2	0	-2		1	1	0
		1	1	0		2	2	0		2	2	0
		1	1	0		0	0	0		1	0	-1
Sum 6		6	7	1		8	7	-1		7	6	-1
C	WD	2	2	0	DW	2	1	-1	WW	2	0	-2
		1	2	1		1	0	-1		1	0	-1
		2	1	-1		1	1	0		2	1	-1
		2	2	0		2	0	-2		2	0	-2
		2	2	0		2	2	0		0	2	2
		2	2	0		1	0	-1		1	1	0
		2	2	0		2	2	0		1	1	0
Sum 7		13	13	0		11	6	-5		9	5	-4
D	DW	2	1	-1	WW	2	2	0	DD	1	1	0
		1	2	1		2	2	0		0	0	0
		1	1	0		1	0	-1		1	1	0
		1	0	-1		1	0	-1		1	1	0
		1	1	0		1	0	-1		1	1	0
		2	2	0		2	2	0		0	0	0
Sum 6		8	7	-1		9	6	-3		4	4	0

Table 38

PMC1 CE Scores

	Papers				Magnets				Crystals			
	First Experiment				Second Experiment				Third Experiment			
Group	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
A	WW	1	0	-1	DW	1	1	0	WD	1	0	-1
		1	1	0		1	1	0		2	0	-2
		2	2	0		2	1	-1		2	2	0
		1	1	0		1	1	0		1	0	-1
		1	1	0		2	2	0		2	0	-2
Sum 5		6	5	-1		7	6	-1		8	2	-6
B	DD	2	2	0	WW	0	0	0	DW	2	1	-1
		2	1	-1		2	1	-1		2	2	0
		1	1	0		1	1	0		2	1	-1
		0	1	1		0	1	1		0	0	0
Sum 4		5	5	0		3	3	0		6	4	-2
C	WD	0	0	0	DD	1	1	0	WW	2	2	0
		0	0	0		1	2	1		2	2	0
		0	0	0		1	1	0		0	0	0
		0	1	1		1	1	0		1	1	0
		2	1	-1		1	1	0		1	1	0
		0	1	1		1	1	0		1	1	0
		0	0	0		1	1	0		0	0	0
Sum 7		2	3	1		7	8	1		7	7	0
D	DW	1	1	0	WD	1	1	0	DD	2	2	0
		2	1	-1		1	1	0		2	1	-1
		2	1	-1		1	1	0		0	0	0
		0	1	1		1	2	1		2	1	-1
		0	0	0		1	2	1		2	0	-2
		1	0	-1		1	1	0		1	0	-1
		0	1	1		1	0	-1		2	2	0
		2	1	-1		1	2	1		2	0	-2
Sum 8		8	6	-2		8	10	2		13	6	-7

Table 39
PMC2 CE Scores

	Papers First Experiment				Magnets Second Experiment				Crystals Third Experiment			
Group	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
A	WW	1	1	0	DD	1	2	1	WD	0	0	0
		1	2	1		2	2	0		0	0	0
		1	1	0		1	2	1		2	0	-2
		1	1	0		1	1	0		0	1	1
		1	1	0		1	2	1		0	0	0
		0	0	0		1	1	0		0	0	0
		1	1	0		2	1	-1		2	0	-2
		1	0	-1		2	2	0		2	2	0
Sum 8		7	7	0		11	13	2		6	3	-3
B	DD	0	0	0	DW	1	1	0	DW	1	0	-1
		0	0	0		1	2	1		0	2	2
		1	1	0		1	0	-1		1	1	0
		1	0	-1		2	2	0		0	0	0
		1	1	0		2	1	-1		2	1	-1
Sum 5		3	2	-1		7	6	-1		4	4	0
C	WD	1	1	0	WW	1	2	1	WW	2	0	-2
		0	1	1		1	1	0		1	1	0
		1	1	0		1	1	0		0	0	0
		0	0	0		1	1	0		1	1	0
		1	0	-1		1	1	0		0	0	0
Sum 5		3	3	0		5	6	1		4	2	-2
D	DW	1	0	-1	WD	1	2	1	DD	1	1	0
		1	1	0		1	1	0		0	0	0
		1	0	-1		0	1	1		1	1	0
		1	1	0		1	1	0		0	2	2
		1	1	0		1	1	0		0	0	0
		1	1	0		1	1	0		0	0	0
		1	1	0		2	2	0		2	2	0
Sum 7		7	5	-2		7	9	2		4	6	2

Table 40
PCM1 CE Scores

	Papers First Experiment				Crystals Second Experiment				Magnets Third Experiment			
Group	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
A	WW	0	0	0	DW	1	0	-1	DD	1	2	1
		1	0	-1		2	0	-2		1	1	0
		1	0	-1		2	0	-2		1	0	-1
		0	1	1		2	1	-1		1	1	0
		1	1	0		0	1	1		2	2	0
		1	2	1		1	1	0		1	1	0
Sum 6		4	4	0		8	3	-5		7	7	0
B	DD	0	0	0	WD	2	2	0	WW	2	2	0
		1	0	-1		1	2	1		2	2	0
		0	1	1		1	1	0		0	0	0
		1	2	1		1	0	-1		2	2	0
		1	1	0		2	2	0		1	1	0
		2	1	-1		2	2	0		1	2	1
Sum 6		5	5	0		9	9	0		8	9	1
C	WD	0	0	0	WW	1	0	-1	DW	1	1	0
		1	1	0		0	0	0		2	1	-1
		1	0	-1		1	0	-1		1	2	1
		2	0	-2		0	0	0		2	2	0
		2	0	-2		2	0	-2		2	2	0
		2	0	-2		2	2	0		2	2	0
Sum 6		8	1	-7		6	2	-4		10	10	0
D	DW	0	0	0	DD	2	2	0	WD	1	2	1
		1	1	0		1	1	0		0	0	0
		1	1	0		2	0	-2		2	2	0
		2	1	-1		1	1	0		2	2	0
		1	2	1		2	2	0		2	2	0
Sum 5		5	5	0		8	6	-2		7	8	1

Table 41
PCM2 CE Scores

	Papers First Experiment				Crystals Second Experiment				Magnets Third Experiment			
Group	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
A	WW	1	1	0	WD	2	1	-1	DW	2	1	-1
		0	0	0		1	1	0		1	1	0
		1	0	-1		0	0	0		1	1	0
		1	0	-1		1	1	0		2	2	0
		1	1	0		2	0	-2		1	1	0
Sum 5		4	2	-2		6	3	-3		7	6	-1
B	DD	1	1	0	WW	2	2	0	WD	2	0	-2
		1	1	0		1	1	0		2	2	0
		0	0	0		2	2	0		2	1	-1
		0	0	0		2	2	0		0	1	1
		1	1	0		1	1	0		2	2	0
Sum 5		3	3	0		8	8	0		8	6	-2
C	WD	1	2	1	DW	2	0	-2	DD	1	1	0
		0	0	0		2	0	-2		2	2	0
		1	0	-1		2	2	0		1	1	0
		1	1	0		2	1	-1		1	2	1
		1	1	0		2	0	-2		1	2	1
		1	1	0		1	0	-1		1	1	0
		1	0	-1		2	1	-1		2	2	0
		1	0	-1		2	2	0		2	2	0
Sum 8		7	5	-2		15	6	-9		11	13	2
D	DW	1	2	1	DD	1	0	-1	WW	2	2	0
		1	1	0		1	0	-1		1	1	0
		1	1	0		2	0	-2		2	2	0
		1	2	1		1	0	-1		2	2	0
Sum 4		4	6	2		5	0	-5		7	7	0

Table 42

.CMP1 D Scores

	Crystals				Magnets				Papers			
	First Experiment				Second Experiment				Third Experiment			
Group	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
A	WW	4	4	0	DW	4	3	-1	WD	2	2	0
		2	1	-1		5	2	-3		1	3	2
		4	4	0		4	4	0		2	4	2
		2	2	0		4	2	-2		2	3	1
		4	1	-3		6	4	-2		2	4	2
		2	2	0		3	3	0		1	3	2
		2	2	0		6	4	-2		1	3	2
		2	2	0		4	4	0		1	1	0
Sum 8		22	18	-4		36	26	-10		12	23	11
B	DD	3	2	-1	WD	2	5	3	DW	4	2	-2
		4	4	0		4	5	1		4	4	0
		4	4	0		3	4	1		3	1	-2
		3	3	0		1	4	3		2	2	0
		4	3	-1		6	5	-1		3	2	-1
		3	2	-1		4	5	1		2	2	0
		1	1	0		3	6	3		1	1	0
Sum 7		22	19	-3		23	34	11		19	14	-5
C	WD	4	4	0	WW	3	1	-2	DD	3	4	1
		2	2	0		4	2	-2		0	0	0
		2	1	-1		2	2	0		2	3	1
		2	2	0		3	2	-1		2	2	0
		4	4	0		3	3	0		4	4	0
		4	3	-1		4	4	0		2	3	1
Sum 6		18	16	-2		19	14	-5		13	11	3
D	DW	4	2	-2	DD	5	5	0	WW	2	2	0
		4	1	-3		6	6	0		1	2	1
		4	2	-2		6	6	0		3	4	1
		2	2	0		3	3	0		2	2	0
		3	1	-2		5	4	-1		2	3	1
		4	2	-2		5	5	0		2	2	0
Sum 6		21	10	-11		30	29	-1		12	15	3

Table 43
CMP2 D Scores

	Crystals First Experiment				Magnets Second Experiment				Papers Third Experiment			
Group	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
A	WW	1	1	0	DD	5	5	0	DW	3	2	-1
		4	4	0		5	4	-1		4	4	0
		3	4	1		3	4	1		2	2	0
		4	4	0		4	4	0		4	2	-2
		4	2	-2		5	4	-1		3	0	-3
Sum 5		16	15	-1		22	21	-1		16	11	-6
B	DD	3	3	0	DW	5	4	-1	WD	4	4	0
		3	1	-2		2	4	2		1	1	0
		1	1	0		5	4	-1		2	2	0
		4	2	-2		3	2	-1		2	1	-1
		3	2	-1		4	2	-2		4	1	-3
Sum 5		14	9	-5		19	16	-3		13	9	-4
C	WD	3	2	-1	WW	3	3	0	DD	3	3	0
		1	2	1		4	4	0		4	4	0
		1	0	-1		2	3	1		3	2	-1
		4	2	-2		4	4	0		4	3	-1
Sum 4		9	6	-3		13	14	1		14	12	-2
D	DW	4	4	0	WD	3	4	1	WW	4	2	-2
		1	1	0		3	3	0		1	0	-1
		3	1	-2		4	5	1		2	2	0
		4	4	0		2	2	0		4	4	0
		4	0	-4		5	3	-2		4	4	0
		1	1	0		1	3	2		2	2	0
Sum 6		17	11	-6		18	20	2		17	14	-3

Table 44
CPM1 D Scores

	Crystals First Experiment				Papers Second Experiment				Magnets Third Experiment			
Group	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
A	WW	2	2	0	DD	2	1	-1	WD	3	3	0
		2	2	0		0	1	1		0	4	4
		4	1	-3		3	2	-1		3	4	1
		4	1	-3		2	1	-1		2	5	3
		1	1	0		2	1	-1		4	5	1
		1	1	0		2	2	0		2	3	1
		2	2	0		3	2	-1		2	4	2
Sum 7		16	10	-6		14	10	-4		16	28	12
B	DD	3	3	0	WD	4	2	-2	DW	4	1	-3
		3	1	-2		2	3	1		2	2	0
Sum 2		6	4	-2		6	5	-1		6	3	-3
C	WD	1	2	1	DW	3	2	-1	WW	1	1	0
		1	1	0		2	2	0		2	2	0
		4	2	-2		2	2	0		2	3	1
		1	2	1		3	1	-2		4	4	0
		1	2	1		3	2	-1		2	4	2
		1	3	2		2	2	0		6	4	-2
Sum 6		9	12	3		15	11	-4		17	18	1
D	DW	4	4	0	WW	4	4	0	DD	5	5	0
		3	1	-2		2	2	0		4	5	1
		4	4	0		4	4	0		3	4	1
		4	4	0		4	2	-2		5	3	-2
		1	1	0		1	1	0		4	6	2
		2	2	0		4	2	-2		1	2	1
		4	1	-3		1	1	0		2	4	2
Sum 7		22	17	-5		20	16	-4		24	29	5

Table 45
CPM2 D Scores

	Crystals First Experiment				Papers Second Experiment				Magnets Third Experiment			
Group	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
A	WW	1	1	0	DW	3	2	-1	DD	4	4	0
		1	3	2		2	2	0		3	4	1
		4	1	-3		4	2	-2		6	6	0
		2	1	-1		3	2	-1		3	3	0
		4	1	-3		4	2	-2		4	3	-1
		1	1	0		3	2	-1		5	4	-1
Sum 6		13	8	-5		19	12	-7		25	24	-1
B	DD	1	2	1	WD	2	3	1	WW	3	4	1
		3	4	1		3	2	-1		4	4	0
		3	3	0		2	3	1		4	2	-2
		1	1	0		2	4	2		4	4	0
		2	2	0		1	2	1		4	4	0
		4	2	-2		1	1	0		3	4	1
		2	2	0		2	2	0		4	2	-2
Sum 7		16	16	0		13	17	4		26	24	-2
C	WD	3	2	-1	WW	4	4	0	DW	3	2	-1
		2	1	-1		3	2	-1		3	2	-1
		2	1	-1		3	1	-2		4	4	0
		4	2	-2		4	4	0		5	6	1
		2	1	-1		1	1	0		6	4	-2
		1	2	1		2	2	0		3	2	-1
		1	1	0		2	2	0		5	4	-1
Sum 7		15	10	-5		19	16	-3		29	24	-5
D	DW	2	2	0	DD	2	2	0	WD	6	6	0
		1	2	1		1	1	0		4	4	0
		2	2	0		2	2	0		6	5	-1
		1	1	0		3	3	0		2	4	2
		1	1	0		2	2	0		3	3	0
		2	1	-1		3	2	-1		4	4	0
		4	1	-3		3	3	0		6	6	0
		3	1	-2		2	2	0		2	4	2
		3	1	-2		2	2	0		3	4	1
		1	4	3		4	1	-3		4	5	1
Sum 10		20	16	-4		24	20	-4		40	45	5

Table 46
MPCl D Scores

	Magnets First Experiment				Papers Second Experiment				Crystals Third Experiment			
Group	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
A	WW	2	3	1	WD	2	3	1	DW	2	2	0
		4	4	0		2	3	1		2	1	-1
		4	4	0		4	4	0		2	1	-1
		4	4	0		2	3	1		0	1	1
Sum 4		14	15	1		10	13	3		6	5	-1
B	DD	4	4	0	WW	4	4	0	WD	4	1	-3
		2	2	0		4	4	0		4	2	-2
		5	5	0		4	2	-2		4	4	0
		4	4	0		1	2	1		1	1	0
		6	6	0		1	1	0		4	2	-2
		4	3	-1		2	2	0		4	2	-2
Sum 6		25	24	-1		16	15	-1		21	12	-9
C	WD	1	3	2	DW	2	3	1	DD	2	2	0
		4	4	0		3	2	-1		2	3	1
		4	4	0		4	4	0		4	3	-1
		3	5	2		3	1	-2		2	1	-1
		0	4	4		1	1	0		2	2	0
		2	4	2		3	2	-1		3	2	-1
Sum 6		14	24	10		16	13	-3		15	13	-2
D	DW	5	2	-3	DD	2	3	1	WW	2	1	-1
		4	2	-2		2	3	1		1	2	1
		4	1	-3		2	2	0		1	1	0
		5	3	-2		3	4	1		4	1	-3
		4	2	-2		2	3	1		1	1	0
		4	3	-1		2	3	1		2	2	0
		2	4	2		2	3	1		4	3	-1
Sum 7		28	17	-11		15	21	6		15	11	-4

Table 47
MPC2 D Scores

	Magnets First Experiment				Papers Second Experiment				Crystals Third Experiment			
Group	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
A	WW	3	4	1	DW	2	2	0	WD	4	2	-2
		4	4	0		2	2	0		4	2	-2
		4	4	0		2	2	0		4	4	0
		4	4	0		2	1	-1		4	2	-2
Sum 4		15	16	1		8	7	-1		16	10	-6
B	DD	5	4	-1	WD	2	2	0	DW	2	2	0
		4	4	0		2	2	0		2	2	0
		3	4	1		4	4	0		1	4	3
		4	5	1		4	4	0		4	1	-3
		3	4	1		4	4	0		4	2	-2
Sum 5		19	21	2		16	16	0		13	11	-2
C	WD	4	4	0	WW	4	3	-1	DD	3	2	-1
		4	5	1		2	2	0		3	2	-1
		4	4	0		4	1	-3		4	1	-3
		4	4	0		2	2	0		1	4	3
Sum 4		16	17	1		12	8	-4		11	9	-4
D	DW	5	4	-1	DD	2	2	0	WW	1	1	0
		3	2	-1		2	2	0		4	2	-2
		3	2	-1		2	2	0		3	3	0
		5	4	-1		3	3	0		2	2	0
		5	2	-3		4	2	-2		4	4	0
		3	4	1		2	2	0		2	1	-1
		5	4	-1		2	2	0		2	4	2
Sum 7		29	22	-7		17	15	-2		18	17	-1

Table 48

MCP1 D Scores

	Magnets				Crystals				Papers			
	First Experiment				Second Experiment				Third Experiment			
Group	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
A	WW	4	4	0	WD	2	1	-1	DD	3	3	0
		2	2	0		2	2	0		3	4	1
		2	2	0		2	3	1		3	3	0
		4	4	0		4	2	-2		3	4	1
		2	2	0		2	3	1		2	2	0
		4	4	0		4	2	-2		4	2	-2
		4	4	0		4	2	-2		4	4	0
		4	4	0		2	2	0		2	2	0
Sum 8		26	26	0		22	17	-5		24	24	0
B	DD	2	3	1	DW	1	1	0	WW	2	2	0
		5	5	0		2	1	-1		1	1	0
		5	4	-1		2	3	1		2	4	2
		6	6	1		4	2	-2		1	2	1
		6	5	-1		4	4	0		4	4	0
		2	2	0		2	2	0		4	2	-2
Sum 6		26	25	-1		15	13	-2		14	15	1
C	WD	3	5	2	DD	2	2	0	DW	3	2	-1
		2	4	2		2	2	0		3	2	-1
		2	4	2		2	1	-1		4	2	-2
		4	3	-1		2	1	-1		1	1	0
		4	6	2		3	1	-2		3	1	-2
		4	5	1		4	1	-3		3	2	-1
		2	6	4		1	2	1		3	1	-2
		2	4	2		2	1	-1		4	2	-2
		4	4	0		1	1	0		3	2	-1
Sum 9		27	41	14		20	12	-8		27	15	-12
D	DW	4	4	0	WW	1	1	0	WD	2	3	1
		4	4	0		4	2	-2		2	3	1
		5	4	-1		4	1	-3		4	4	0
		3	2	-1		1	1	0		2	3	1
		5	2	-3		2	2	0		4	4	0
Sum 5		21	16	-5		12	7	-5		14	17	3

Table 49
MCP2 D Scores

	Magnets First Experiment				Crystals Second Experiment				Papers Third Experiment			
Group	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
A	WW	4	3	-1	DD	3	2	-1	WD	1	3	2
		4	4	0		2	2	0		2	3	1
		3	4	1		4	2	-2		1	4	3
		4	2	-2		3	3	0		2	1	-1
		3	4	1		2	3	1		2	3	1
		4	4	0		4	4	0		4	3	-1
Sum 6		22	21	-1		18	16	-2		12	17	5
B	DD	4	5	1	WD	3	4	1	DW	2	2	0
		3	3	0		4	4	0		3	2	-1
		5	4	-1		2	2	0		2	2	0
		4	4	0		4	2	-2		2	2	0
		4	4	0		4	4	0		4	4	0
		3	4	1		1	1	0		3	1	-2
Sum 6		23	24	1		18	17	-1		16	13	-3
C	WD	4	6	2	DW	4	2	-2	WW	4	1	-3
		4	5	1		3	1	-2		2	1	-1
		4	5	1		2	4	2		4	3	-1
		4	6	2		4	2	-2		4	1	-3
		5	6	1		4	4	0		2	4	2
		4	5	1		2	1	-1		2	2	0
		4	5	1		4	4	0		2	2	0
Sum 7		29	38	9		23	18	-5		20	14	-6
D	DW	5	2	-3	WW	4	4	0	DD	3	3	0
		5	6	1		4	4	0		1	1	0
		3	2	-1		2	1	-1		3	2	-1
		3	1	-2		3	1	-2		3	2	-1
		3	2	-1		3	1	-2		3	3	0
		6	4	-2		4	4	0		1	1	0
Sum 6		25	17	-8		20	15	-5		14	12	-2

Table 50
PMC1 D Scores

	Papers				Magnets				Crystals			
	First Experiment				Second Experiment				Third Experiment			
Group	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
A	WW	2	1	-1	DW	2	3	1	WD	2	1	-1
		2	2	0		3	2	-1		4	1	-3
		4	4	0		5	2	-3		4	4	0
		2	2	0		3	2	-1		3	3	0
		2	2	0		4	4	0		4	2	-2
Sum 5		12	11	-1		17	13	-4		17	11	-6
B	DD	4	4	0	WW	1	1	0	DW	4	2	-2
		4	4	0		3	2	-1		4	4	0
		3	2	-1		2	2	0		4	2	-2
		3	3	0		2	2	0		3	1	-2
Sum 4		14	13	-1		8	7	-1		15	9	-6
C	WD	1	1	0	DD	3	3	0	WW	4	4	0
		1	1	0		3	4	1		4	4	0
		1	1	0		4	4	0		1	1	0
		1	2	1		4	3	-1		3	2	-1
		4	3	-1		4	5	1		2	2	0
		1	2	1		4	5	1		2	2	0
		0	1	1		2	2	0		2	1	-1
Sum 7		9	11	2		24	26	2		18	16	-2
D	DW	3	2	-1	WD	2	4	2	DD	4	4	0
		4	2	-2		2	4	2		4	3	-1
		4	2	-2		2	4	2		3	2	-1
		0	2	2		2	4	2		4	3	-1
		1	1	0		2	5	3		4	3	-1
		3	1	-2		2	5	3		3	1	-2
		1	2	1		2	4	2		4	4	0
		4	2	-2		2	4	2		4	1	-3
Sum 8		20	14	-6		16	34	18		30	21	-9

Table 51
PMC2 D Scores

	Papers First Experiment				Magnets Second Experiment				Crystals Third Experiment			
Group	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
A	WW	2	2	0	DD	4	5	1	WD	1	2	1
		2	4	2		5	5	0		1	1	0
		2	2	0		5	5	0		4	1	-3
		2	2	0		3	5	2		1	3	2
		2	2	0		4	4	0		1	2	1
		1	1	0		5	6	1		1	2	1
		2	2	0		5	5	0		4	2	-2
		2	1	-1		5	5	0		4	4	0
Sum 8		15	16	1		36	40	4		17	17	0
B	DD	1	1	0	DW	4	2	-2	DW	3	1	-2
		2	1	-1		5	5	0		1	4	3
		2	2	0		4	2	-2		2	2	0
		2	1	-1		5	4	-1		2	1	-1
		3	3	0		5	2	-3		4	2	-2
Sum 5		10	8	-2		23	15	-8		12	10	-2
C	WD	2	3	1	WW	2	4	2	WW	4	1	-3
		1	3	2		2	2	0		2	2	0
		2	2	0		2	2	0		1	1	0
		1	2	1		3	3	0		2	2	0
		2	2	0		2	2	0		1	1	0
Sum 5		8	12	4		11	13	2		10	7	-3
D	DW	2	1	-1	WD	2	5	3	DD	3	2	-1
		2	2	0		2	3	1		1	1	0
		2	1	-1		2	5	3		2	3	1
		3	2	-1		2	5	3		2	4	2
		3	2	-1		2	4	2		1	2	1
		3	2	-1		2	4	2		2	2	0
		3	2	-1		4	5	1		4	4	0
Sum 7		18	12	-6		16	31	15		15	18	3

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Table 52
PCM1.D Scores

	Papers				Crystals				Magnets			
	First Experiment				Second Experiment				Third Experiment			
Group	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
A	WW	2	1	-1	DW	3	1	-2	DD	2	4	2
		2	1	-1		4	1	-3		4	4	0
		2	1	-1		4	1	-3		3	3	0
		1	2	1		4	2	-2		3	5	2
		2	2	0		2	2	0		6	6	0
		2	4	2		3	2	-1		4	6	2
Sum 6		11	11	0		20	9	-11		22	28	6
B	DD	1	1	0	WD	4	4	0	WW	4	4	0
		3	2	-1		2	4	2		4	4	0
		2	2	0		2	2	0		3	1	-2
		4	4	0		4	2	-2		4	4	0
		2	2	0		4	4	0		2	2	0
		4	3	-1		4	4	0		2	4	2
Sum 6		16	14	-2		20	20	0		19	19	0
C	WD	1	1	0	WW	2	1	-1	DW	3	2	-1
		2	3	1		1	1	0		5	2	-3
		2	1	-1		3	1	-2		3	4	1
		4	2	-2		1	1	0		5	4	-1
		4	1	-3		4	1	-3		6	4	-2
		4	1	-3		4	4	0		4	4	0
Sum 6		17	9	-8		15	9	-6		26	20	-6
D	DW	2	1	-1	DD	4	4	0	WD	2	5	3
		3	2	-1		2	2	0		2	3	1
		2	2	0		4	2	-2		4	5	1
		4	2	-2		3	3	0		4	5	1
		3	4	1		4	4	0		4	5	1
Sum 5		14	11	-3		17	15	-2		16	23	7

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SUMMARY

The Effects of Shifting Medium of Expression on the Use of Concepts Among Children

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BACKGROUND

Many ideas can be expressed in more than one medium of expression, such as oral or written language, mathematics, pictorial representation, and so on, each of these involving distinct communications codes. It sometimes appears that a principle or a concept that is formed in one context is difficult to use if some other form of expression is required. The effect on adequacy of expression of having to shift from one code to another is the general problem considered in this study. It is one of the problems involved in transfer of training.

Failure to transfer school learning to a variety of situations has always been one of the major difficulties facing educators. Again there are a number of controversies concerning the guidance of learning and "learning by discovery", which are also arguments about transfer of training; these arguments rarely consider the form of expression used in the original learning and transfer situation as a relevant variable. However, in a previous study, Wilder and Green found that shifting form of expression or code interfered with expressing an explanatory concept but not with straight description, suggesting that this is an important factor in performance.

Therefore, the specific portion of the general problem explored in this study is the content dimensions which produced the different result in the prior study. (1) Does shifting code inhibit expression of other explanatory concepts? (2) Is the shifting code irrelevant to the description of other physical phenomena? (3) Could the inhibiting effect have appeared in the cause and effect concept (explanatory) scores and not in the discrimination (description) scores because of some unidentified artifact in the first set of materials used.

OBJECTIVES

The main objective of the study was to obtain evidence as to the degree to which the effect noted previously by Wilder and Green is a general phenomenon independent of material or content. Specifically then, the objectives were:

a. To confirm, with different materials, the results of that previous investigation (i.e., that shifting from one code of expression to another inhibited the expression of a concept which explained a physical change, but did not inhibit the description of that change).

b. To explore the reasons for the difference in the influence of shifting medium on discrimination and concept scores.

PROCEDURE

I Materials

The first step in the project was to develop materials for experiments which paralleled those used in the previous study such that the experiments could be performed in one session instead of the two weeks required by the plants. In the previous study, the plant cuttings received two different amounts of light which caused them to grow differently sized leaves, roots, etc. This was taught by demonstration only. The children watched without talking while two identical cuttings were made from the coleus plant. One cutting was placed in a sunny window, the other in a bookcase. The children were told to watch the plants for two weeks, at which time E would return to ask them "What happened?" and "Why?" They were not to discuss the plants with anyone until E told them the experiment was completed.

The materials to be developed had to meet certain requirements:

1. Again the concept had to be taught by demonstration only. This was necessary because any instruction using a code of expression would affect the subsequent expression of the children's learning.

2. The concepts used had to be similar in form but not in content. Two plant cuttings received different amounts of light, causing them to grow differently. This idea was called the cause and effect concept (CE).

In the new experiment, the agent had to occur in a greater and lesser amount and act upon something to cause change. Also, the things acted upon, as was the case with the plants, would have to change in a discriminably different manner to two different amounts of the agent. The end result had to be visibly different, permitting us to record a discrimination (D) independent of noting the CE.

3. The agent could be used in only one of the experiments.

4. The CE must be equally easy to express both in writing and in drawing.

5. For the second expression, the materials acted upon by the agent must be similar, but different from the materials used for the first expression, since, in the previous study of the plants, for the second expression, the original coleus plants were replaced by two begonia cuttings not seen before by the children. The children were told: "These were grown just like those you saw grow in the classroom. Now tell what happened and why."

6. Naturally, the materials had to be unfamiliar to the subjects but neither too hard nor too easy for them to understand.

Three sets of materials appropriate to the study were developed and tried out in a number of fourth grade classes in DeKalb County, Georgia, in the Spring of 1965. These were: (a) two different amounts of light caused light sensitive papers to change color, the shades of the color differing with the amounts of light; (b) two different amounts of electricity caused the electromagnets to pick up different bar weights; (c) two different amounts of heat caused crystals in sodium silicate to grow to different sizes.

II Subjects

As in the previous study, subjects were fourth graders taking advanced studies in the DeKalb County School System, a largely white (about 90%) bedroom county, bordering Atlanta, Georgia. Scores from 289 children in 12 schools were used. These schools were in middle class white neighborhoods (the county is very thoroughly segregated; school desegregation remains token), as pilot studies had indicated the need to have subjects with expressive facility if scorable protocols were to be obtained. Thus, at the fourth grade level, it was necessary to select brighter than average subjects from better than average socioeconomic surroundings.

Within each classroom the children were divided into four groups more or less randomly, i.e., haphazardly. This was done by E on the first day in the classroom. The groups were approximately equal in size the first day. They did not stay that way because (a) there were absences (28) on the second or third day, (b) a number of S's (40) both wrote and drew on at least one expression, and (c) a few S's (7) followed treatment sequences not assigned. The remaining 289 S's were distributed in groups varying from two to ten.

III Design

As noted above, four groups were set up in each school the first day. These groups were designated WW, DD, WD, and DW indicating whether they wrote (W) or drew (D) on the first and second expressions. In each school, the first experiment was done on a Monday with one-third of the schools doing the papers, one-third the magnets, and one-third the crystals; the experiments were systematically varied over schools for the three days.

The second experiment was conducted on the Wednesday, and the third on the Friday of the same week. No group had the same treatment twice, i.e., the writing and/or drawing sequence was different on each of the three days.

Three E's and a substitute (used six times: magnets four times, crystals once, papers once) presented the experiments to the children. Each E was assigned one of the three experiments, which he presented to each of the 12 schools during a three week period. Thus, any effects apparently due to materials or "experiments" can be equally well considered the effects of the particular E.

These four E's also scored the protocols, each scoring the materials he collected and those of one other. Thus every paper was scored twice. Disagreements were settled by the senior author. The correlation between judges was .96 for CE scores and .99 for D scores.

IV Classroom Procedure

Each experiment took approximately one hour and thirty-five minutes. In each case, E had the children watch the demonstration, coming up to look closely at the materials in the case of the papers and crystals. Then the S's wrote or drew as directed, answering the questions, "What happened?" and "Why?" Typically, this took them about twenty minutes. Next, a second demonstration with slightly different materials was given, followed by a second attempt to answer the question by drawing or writing. Half of those who drew first wrote, half of those who wrote first drew second, and the remainder used the same medium twice. After the second expression on the third day (Friday), the whole affair, including each experiment, was explained to the students.

RESULTS

The data relevant to the objectives of the study are the changes in score from first expression to second expression as influenced by mode of expression.

Since the number of pupils in the four treatment groups in each class (school) varied from two to ten, the mean for each treatment group in each school for each set of materials was found and treated as a single score. This procedure avoids any bias from unequal numbers in any treatment in any school with any materials, and balances out all direct drawing and writing effects.

The comparison relevant to the principal questions asked is between the shifting scores (WD & DW) and the repetition scores (WW & DD). These pairs of means were combined and the differences between them found. A mean R-S difference score is the combination of all the scores of all the students in the classs for that experiment. Drawing and writing per se are fully controlled (i.e., balanced out) in these differences scores.

All CE change R-S differences favor repetition over shifting and all but one permit rejection of the null hypotheses at standard levels of significance. This analysis indicates that there is a shifting effect in these CE change score differences. CE change scores are higher when code of expression is not changed then when it is. This confirms the result of the previous study. The shifting effect does not appear to be a function of either order of presentation or material unless the two interact so as to mask their effects.

Another way to approach these data is to treat each CE score of each subject as a separate entity and perform a regression analysis of variance, adjusting sequentially and cumulatively for each of the variables discussed. The results of such an approach looking first at school effects, second at materials, third at order, and fourth at shifting show the second and fourth variables produced significant effects. This analysis not only confirmed the results of the first analysis, but also revealed that there were significant differences among the materials in CE change scores. The crystals means were positive in only one instance, indicating that, regardless of treatment or school, second expression was more difficult than the first for the crystals. This almost uniform negative transfer appeared in a less marked form in the papers and was not found among the magnet means, which were positive as often as not.

Tests of the shifting hypotheses among mean D change scores were made parallel to those among the CE means. In the overall comparison, no significant effect was present nor did any appear when the differences were arranged by materials. When arranged by order of experiment, a shifting effect, significant at the .05 level, appeared for the third experiment. The most parsimonious interpretation of this last finding is that it represents a type I error.

In sum, as before, the data support a conclusion of no shifting effect for D change scores. The shifting effect in the CE change scores is not present in the D change scores.

It is interesting to note that this conclusion is restricted to the R-S differences. The differences by material in CE change scores noted above are reflected almost exactly in the D scores.

As was the case among the CE scores, almost all the mean D scores for crystals were negative. In other words, the second set of crystals was harder to describe and harder to explain. In contrast, the magnets apparently created no such problems since both the mean CE and the mean D scores were positive as often as not. The frequencies for the papers experiment fell between the other two, that is, there was a tendency for second expression to be more difficult than first (transfer is negative) but the tendency was less marked than in the crystals experiment.

The fact that both CE and D scores show these material effects emphasizes the unique nature of the shifting effect which appears only in the CE scores.

CONCLUSIONS

The results of this study fully confirm those of the previous study by Wilder and Green. Clearly, shifting medium or code of expression inhibits the ability to express an inferred causal concept, but does not, in itself, inhibit description of observed characteristics of the material presented. This effect has now been obtained with four different sets of materials. In view of their independence of shifting, the differences among the materials do not appear worth pursuing. The fact that the CE mean differences typically appear within class sized groups after a short period of time suggests that the phenomenon may play a substantial role in school achievement

There are three points to note in interpreting these data before their relevance to educational practice can be fairly considered. One is that all the subjects in both studies were in the 4th grade. It is, therefore, possible that the phenomena noted are developmental and would not appear among younger or older subjects. For example, in Piaget's schema (Inheldder and Piaget, 1958), children at this age (nine and ten) are in the stage of cognitive development in which they can handle concrete, but not formal logical operations. On this basis, one could infer that older individuals (over twelve) would not have serious problems with shifting medium, while younger children (below seven) could not handle the CE concept at all. The latter part of this assertion is almost certainly the case, but what would happen among intellectually mature students is debatable.

A second point about which the data permit no conclusion is the generality of communication codes and media of expression. (The fact that we have treated these as one and the same raises still another question, which will be ignored.) The research which first stimulated the ideas used here was that of Hendrix (1948). She used spoken words and mathematical symbols, but a shift in code is only one of many possible variables involved in her study and was not studied directly. Not only is it uncertain whether or not shifts between other codes would produce effects, but it is not clear whether the effect obtained is large or small, permanent or transitory.

Finally, there is the question of the features of the CE concepts used which were essential for producing the shifting effect. Simple awareness of the differences plainly is not sufficient, albeit definitely essential at some point. What else is involved? Was it the inference of causation? Was it the number of elements going into that inference? Was it the need to draw an inference along, i.e., would other sorts of inferences produce a shifting effect? Would it have occurred if the second demonstration had been completed while the children watched as they did the first?

The answers to these questions partly determine the implications of the data for education. Nevertheless, it is evident that, at least among children in the middle grades, requiring a shift in medium of expression can interfere with the adequacy with which students explain inferences about causation. It may further explain many of the puzzling cases of student inability to write down explanations their teachers had been sure they understood, to say nothing of the often incredible errors students commit when working with "word problems" in mathematics.

It is, of course, not known whether it is the expression of the idea or its understanding that is inhibited, but obviously there is some advantage in having students use the code of expression most relevant to the use of the idea learned from the beginning. At least some of the time our penchant for having students put ideas into words on examinations is at best inefficient and at worst misleading to all, since even the students themselves tend to believe their own test scores.

The domain in which these data have the greatest possibility of helping education is in the design of "discovery learning" procedures which often require students to draw inferences based on observation. In this area, there is much confusion about the amount of "guidance" students should be given. We believe that a re-examination of the research in this domain with the existence of the shifting effect in mind would clarify some of the discrepancies in the data since the guidance is often in a different code than that in which the student is working.

Although the nature of the shifting phenomenon still needs exploration, as the uncertainties noted above indicate, some efforts to further improve and systematize instructional procedures calling for discovery might well be undertaken as a consequence of this shifting effect.

BIBLIOGRAPHY

There are fifteen references listed in the final report.

*

Table 53
PCM2 D Scores

		Papers			Crystals				Magnets			
		First Experiment			Second Experiment				Third Experiment			
Group	Treatment	I	II	Ch	Treatment	I	II	Ch	Treatment	I	II	Ch
A	WW	2	2	0	WD	4	4	0	DW	6	4	-2
		1	1	0		2	3	1		5	2	-3
		2	1	-1		1	0	-1		6	2	-4
		2	1	-1		2	3	1		6	4	-2
		2	2	0		4	2	-2		3	2	-1
Sum 5		9	7	-2		13	12	-1		26	14	-12
B	DD	4	3	-1	WW	4	4	0	WD	6	0	-6
		2	2	0		2	2	0		4	5	1
		1	2	1		4	4	0		4	4	0
		1	2	1		4	4	0		1	3	2
		2	2	0		2	2	0		4	5	1
Sum 5		10	11	1		16	16	0		19	17	-2
C	WD	2	4	2	DW	4	1	-3	DD	3	3	0
		1	1	0		4	1	-3		6	5	-1
		2	2	0		4	4	0		4	5	1
		3	2	-1		4	3	-1		4	6	2
		2	2	0		4	1	-3		3	6	3
		2	2	0		2	1	-1		3	3	0
		2	1	-1		4	3	-1		6	6	0
		2	1	-1		4	4	0		6	6	0
Sum 8		16	15	-1		30	18	-12		35	40	5
D	DW	3	4	1	DD	2	2	0	WW	5	5	0
		2	3	1		3	2	-1		2	2	0
		2	2	0		4	2	-2		4	4	0
		3	4	1		3	2	-1		4	4	0
Sum 4		10	12	3		12	8	-4		15	15	0